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TECHNOLOGY DEPT.

February 1937

# TECHNOLOGY REVIEW

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# THE TABULAR VIEW

## MAIL RETURNS

HOW many women read The Review; how many are interested in science news and the impact of technology on modern life? We have often wondered and in divers ways sought an answer. Here, unsought, is one woman's answer, fresh from York, Pa.:

To the Editor: Please accept the thanks of an electrical engineer's wife for the not-too-technical articles you publish in The Review. You see, my college training was in classics; consequently, my scientific knowledge is very general, mostly vague. Now that I am surrounded by things scientific, your articles are a great help. If, for example, the conversation goes astronomical, at least I have read about the expedition to Ak Bulak [The Review, November, 1936] and can sit and listen with a slight glimmer of intelligence in my eyes. You know how a woman hates to be completely in the dark . . .

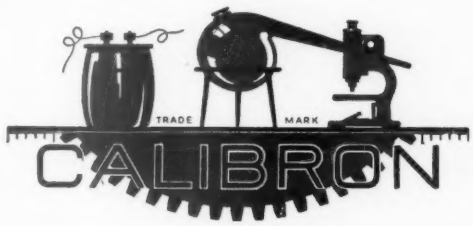
I am so glad that you printed the article, "Technics and the Woman" [The Review, January, 1937]. The author expresses my own feelings, as I never could, and I believe the women of my acquaintance would second those opinions. There is rarely an issue in which there is no article that I can enjoy; The Trend of Affairs and The Institute Gazette I always read. Continue to make The Review interesting to us laywomen and when the subscription fee comes up in the family budget, both budgeteers will assent with loud and hearty ayes.

Helen McCaa (Mrs. J. R.)

May the ayes have it!

## CONTRIBUTORS

IN the great development of America's petroleum industry Robert E. Wilson, '16, has played an important part. Trained as a chemical engineer, one-time associate professor of chemical engineering at the Institute, he became, in 1931, director and vice-president in charge of research and development of the Standard Oil Company of Indiana. At the present time he is vice-chairman and director of the Pan American Petroleum and Transport Company and a director of five associated companies. As the author of more than 50 scientific papers and as the holder of many patents on chemical and engineering processes, he is amply qualified to discuss our patent system and the forces that tend to impede or accelerate scientific advances. His article on page 147 was presented originally as an address at the 100th anniversary of the United States Patent Office. ¶ S. Paul Johnston, '21, is editor of *Aviation*. A recent European trip afforded him many opportunities to observe aeronautical developments abroad and his text and pictures on pages 150 and 151 are the result of this tour. ¶ Frederick G. Fassett, Jr., is assistant professor of English at the Institute and a frequent contributor to The Review. His collaborator, Paul C. Eaton, '27, is a colleague of Professor Fassett's in the Department of English. ¶ F. S. Lincoln, '22, who contributed the cover of this issue of The Review, is recognized as one of America's outstanding architectural photographers. His sunset picture is one of a series of remarkably successful attempts to capture some of the "incredible splendor" of Mont St. Michel.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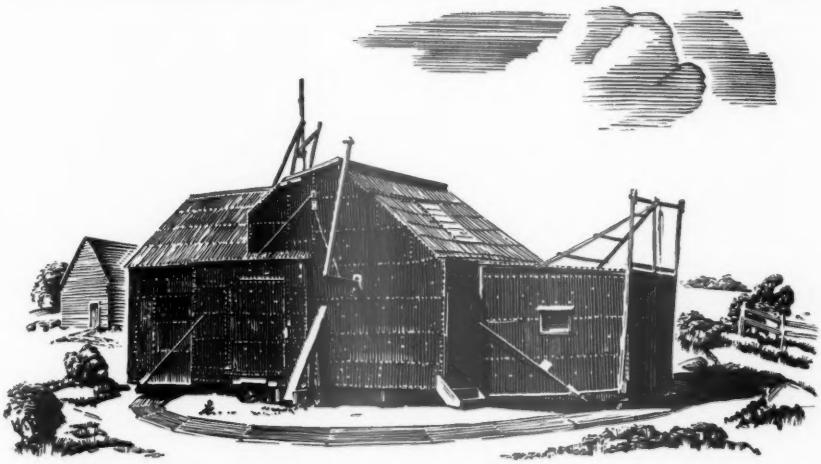
THOMAS A. EDISON

# *Creator of Markets*



Dubbed by the Edison staff "Black Maria," located in the Edison Laboratory grounds at West Orange, N. J., this unpretentious structure of wood frame, covered with black roofing paper, and set on a pivot so that it could be swung around with the sun, was the first motion picture studio. From this humble birth grew the lavish splendor of the world's most romantic billion-dollar industry!

THE invention of the motion picture camera by Thomas A. Edison made possible the practical adaptation of the flexible tapelike film and laid the foundation for today's glamorous billion-dollar industry. Manufacture of motion picture films now consumes approximately 95% of all silver used in the chemical industry—nearly one-third of all silver produced in the United States.

When Thomas A. Edison opened the first central station for the distribution of electric power, he also laid the foundation for vast world markets for copper, lead, zinc, coal and many other commodities. Today the copper industry looks to the electrical industry for its largest consumer and lead used for cable covering and Storage Batteries now accounts for more than 40% of domestic consumption.

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*Cable-length view of Columbia Broadcasting System's 625-foot vertical radiator, Wayne, N. J.*


# THE TECHNOLOGY REVIEW

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EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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TOUR GABRIEL, MONT ST. MICHEL, FRANCE
SILHOUETTED AGAINST THE SAND AND THE SEA OF THE NORMAN COAST
*Copyright by F. S. Lincoln, '22*


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THREE WEEKS MUST BE ALLOWED TO EFFECT CHANGES OF ADDRESS. BOTH OLD AND NEW ADDRESSES SHOULD BE GIVEN.

*From a Photograph of New York's Triborough Bridge by Schnall (Black Star)*

**SOARING STEEL**

THE
TECHNOLOGY
REVIEW

Vol. 39, No. 4 February, 1937

# The Trend of Affairs

## *No Resistance At All*

NOW that physicists have more or less conquered the problem of atomic structure, they have divided their forces and are pushing the further attack in opposing directions. One group is advancing in the direction of still finer detail and is prying open the nucleus to see what makes it work. The other group is proceeding to large-scale phenomena, studying the social behavior of atoms when they are combined to make molecules, or liquids, or solids. Armed with the growing knowledge about the habits of atoms, these investigators are turning back to a study of everyday things — bricks and steel and rubber and oil — a study more searching and much more effective than was possible in the pre-quantum days. Already the results indicate the immense practical value of the research.

At present the study has just begun and only the simplest of atomic communities, the crystals, have been investigated in detail. The crystal, because of its regularity, is in many ways simpler in structure than a single complex molecule or than a liquid. In particular the metal crystal, composed of only one kind of atom, has been studied in some detail. There already exists a fairly voluminous literature on the relation of the structure to the properties and idiosyncrasies of metals: their strength, their specific heats, their optical properties, and so on. Some start has been made toward explaining why the electrons in some metals are foot-loose wanderers and in others are family men, resisting being pressed into service to carry electric current. It is beginning to be clear why so few metals are strongly magnetic. A start has even been made on the alloys.

In connection with these studies, a number of predictions have been made as to the behavior of metals at temperatures near the absolute zero, −273.1 degrees C. At these low temperatures the atoms cease their random vibrations and the crystal becomes as nearly perfect as it can be. The specific heat falls to exceedingly low values, less than a thousandth of its value at ordinary temperatures. Since the atomic jostlings are diminished, the wandering electrons are less impeded and the electrical resistance is reduced. Most of these predictions have been verified by the measurements made at very low temperatures during the last few years.

In one important respect, however, the measurements made at low temperatures did not accord with theoretical predictions. It had been predicted that the electrical resistance would diminish smoothly as the temperature decreased, to become zero at absolute zero. The measurements showed another behavior, more interesting and more puzzling: As the temperature was reduced, the resistance fell; first smoothly, as the predictions would have it; then, at some critical temperature, it suddenly vanished completely. This state of no resistance is called the superconducting state. Current, once induced in a loop of superconductive wire, persists indefinitely without any diminishing of intensity. If a magnetic field is produced inside a hollow piece of ordinary metal and the temperature lowered below the transition point, the field inside the superconducting metal is "frozen in"; a change in the field outside hardly affects it.

These bewildering phenomena had not been expected and are not yet fully understood. Recently Professor J. C. Slater, Head of the Physics Department at Technology, has suggested a plausible explanation. Ordinarily the electrons which carry the current are individualists, wandering through the metal and colliding with the metal atoms, but paying little attention to each other. This state of affairs explains the ordinary resistance of metals. Professor Slater has shown that it is possible for the electrons to be in another state, a coöperative

one somewhat analogous to the magnetic state in iron. In this state the electrons help each other along, and thereby may manage to avoid the collisions with metal atoms which cause the resistance. This state is possible only at low temperatures, for it requires the coöperation of all the electrons, and any large temperature motion of the atoms would jostle one or more electrons loose, thereby destroying the coöperation completely. This explanation seems to be the correct one, although its consequences need further investigation before a final decision can be made.

It is research such as this that will demonstrate the value of a thorough knowledge of atomic structure as an aid in unraveling the practical problems of matter in bulk and will ultimately confound the critics of atom splitting. It is evident now that a knowledge of such abstruse things as electron spin and the exclusion principle is necessary for the complete understanding of such practical problems as the ferromagnetism of Heusler's alloys and the toughness of steel.

*Dr. Croy from Black Star*

## *Remarkable Alloy*

ONE of the most interesting of the new alloys is beryllium-copper, made from one of the oldest metals and one of the newest ones. Beryllium occurs in the mineral beryl, of which mineral emerald and aquamarine are well-known varieties. It is a light metal — density, 1.84 — lighter than aluminum, which has a density of 2.70. It is much harder than aluminum and will, in fact, scratch steel. It needs a high temperature to melt it (1,350 degrees C.), whereas aluminum melts readily at 659 degrees. (Iron melts at 1,533 degrees; gold, at 1,063 degrees.) Commercial beryllium-copper contains 2.0% to 2.25% of beryllium. It is ductile and malleable and can be cold worked or hot worked. After all of the forming operations are completed, articles made from beryllium-copper can be hardened and strengthened by merely heating them for a certain period of time at a comparatively low temperature.

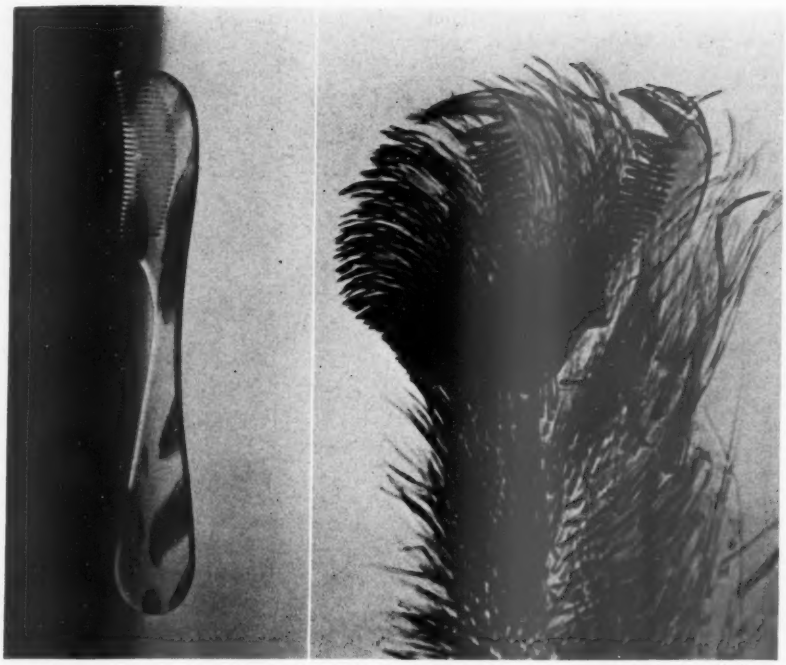
It has been known for many years that copper alloys are hardened by a cold-working process, such as hammering, rolling, drawing, and that such work-hardened alloys can be made soft again by annealing. Beryllium-copper possesses this property; the annealing temperatures which result in softening are limited to a comparatively narrow range in the neighborhood of the melting point. An alloy of 2.15% beryllium, 0.35% nickel, the rest of the metal copper, in the form of a sheet 0.040 inch thick, when softened by annealing at 800 degrees and then quenching in water, had a tensile strength of 60,000 to 80,000 pounds per square inch. The same material, reduced by rolling to half the thickness, had a tensile strength of 118,000 to 130,000 pounds per square inch. Heat treatment alone raised the tensile strength of the soft metal to 170,000 pounds, and cold working and heat treatment together raised it still higher. By suitable methods beryllium-copper articles may be produced which are harder than the hardest bronze. The alloy's resistance to wear is about five times as great as that of the best phosphor bronze and its resistance to fatigue is exceeded only by that of certain of the alloy steels. It may be soldered and welded, and behaves in corrosion tests in about the same way that pure copper does.

Although beryllium-copper is only about four years old, it is finding use in coiled springs, flat springs, diaphragms, switch blades, and so on, where its high resilience and resistance to corrosion and fatigue are desirable; in nonsparking hand tools, hammers, chisels, wrenches, and drift pins, where its hardness and shock resistance are needed; and in bearings, gears, sliding contacts, the handles of surgical instruments, woven wire cloth, and valve parts, where high resistance to wear is advantageous.

## *Neat*

BY tying it down with steel cables, French engineers have strengthened a weakened dam on the Cheurfas River in Algeria. With the dam thus stitched to its steel foundations, the engineers were able to increase the storage level of the reservoir ten feet above its original full height. Cables have been similarly used in basting to its foundation La Jument lighthouse on the West Coast of France.

Other recent engineering activities, neatly handled: ¶ When the Cisco Sports Club, coöperating with the United States Forest Service, set out to stock with



Dr. Croy from Black Star

**TOOLS IMITATING NATURE**

*Striking similarities between natural and man-designed devices are shown on this and the opposite page.*

Clippers. *The mole cricket, like the mole, lives beneath the ground, uses its two front feet to dig and to clip fine roots. Notice the four sharp toes over which a fifth moves in a cutting motion exactly as in the metal clippers shown in parallel.*

Comb. *The foot of the cross spider shows two fine combs which are used to straighten and order its newly spun web, and to enable the spider to cling to the web*

trout the Loch Leven Lakes in the California Sierras, the fingerling trout they placed in the lakes were quickly devoured by predatory fish, such as chubs. With permission of the California Fish and Game Commission, the Club dynamited one lake experimentally, thus killed between fifteen and twenty thousand undesirable fish, and made the lake safe, at least temporarily, for fingerling trout.

¶ The Army Air Corps, fully aware of the danger of too great a dependency upon a product procurable only by import, has built an observation balloon of DuPrene, the synthetic rubber, hoping that the material might prove to be an adequate substitute for rubber. Their substitute, they found, is more than adequate: It is stronger, permits less gas leakage, and is possibly more durable than the natural rubber fabrics. With this evidence in hand, Air Corps engineers sought other air uses for DuPrene, and immediately found a most important one: hose pipe. Now they have an all-purpose synthetic rubber-coated hose which is impervious to the deteriorating qualities of coolants, gasoline, oil, and other chemical solvents.

¶ A new "quota-control" system governs the elevators in the International Building of Rockefeller Center. Calls for a car to make a trip are registered as they come in until a predetermined number or quota of calls selected for that car has been received. Subsequent calls, regardless of the floor sequence, are registered on the next car until its quota is filled. A car stops only at those floors for which calls for it are registered. Another feature of this new elevator installation is the immediate response by light which a potential passenger gets when he pushes the button, thus indicating to him at once, not only that his call is registered but at which door his car will stop.

¶ Through the use of carrier-current telephone equipment built by General Electric, TVA operators at the Norris, Wheeler, and Wilson Dams will be able to talk with each other at will over the 230-mile, 154,000-volt transmission line connecting the three dams. The lines will not only carry high-voltage current for power but at the same time will serve as paths for small high-frequency currents carrying voice signals. A similar system on a small scale has been announced by another firm for use in residences, whereby telephone calls can be made from room to room over the electric light wiring.

## *By-products from Grapefruit*

WHY the grapefruit, like the banana, should have acquired comical connotations is obscure. Its history, if short, is a saga of modern ballyhoo, expansion, and research, in the order named; aside from certain occasions when it has been used as a weapon against crooners and related nuisances, it leads a quiet existence full of good deeds. Even O. O. McIntyre has admitted in his column that, after overcoming an aversion of long standing, he now can't get enough of it — a somewhat surprising statement since the grapefruit industry is now so typically successful that it has a surplus problem.

It was not always thus. In previtamin days, when winter in the North meant a long, unbroken spell of heavy foods without fresh fruits or vegetables and spring sickness was as inevitable as the thaws, exotic fruits were as little known as available. If the consumption of grapefruit among our God-fearing ancestors is an indication, it deserved, more than the apple, its name of the "forbidden fruit."

At the Chicago World's Fair in 1893, however, an attractive display of this handsome fruit enticed a few adventurous epicures to experiment with it on the breakfast table, and by 1890 some 30,000 boxes were being produced in the United States annually. For a long time

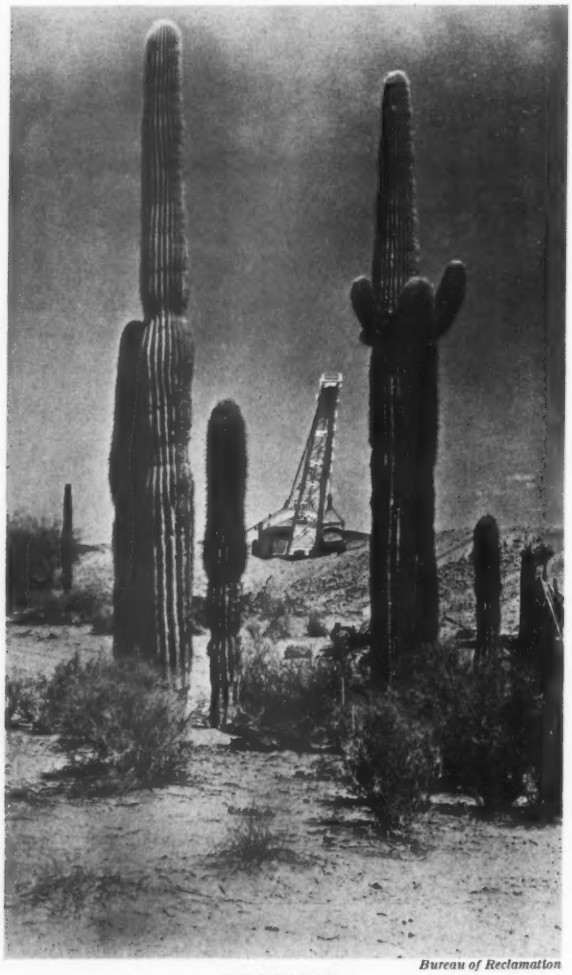
this country remained the only important market, although Canada and the British Isles now take large quantities. Imports into the United Kingdom increased sixfold from 1920 to 1924, but only after surviving a sickly infancy. Greengrocers found that customers bought only once, and who could blame them, since the fruits were so "bloomin' sour" and their peel so bitter.* Expert knowledge about the technique of consuming the fruit was rare, the general method being to attack it, with characteristic British pluck, like an orange. One enterprising English lady published a little pamphlet in 1905, entitled, "The Forbidden Fruit, or Shaddock, or Grapefruit; How to Serve and Eat It."

Today, however, in spite of tremendous sales, growers are often left with large quantities of fruit which is of unsuitable shape or color, frozen, or just without a market, while canneries (15% of the crop is so utilized) have left two pounds of waste for every pound of fruit that reaches the consumer. Through the activities of the Citrus Products Laboratories of the Department of Agriculture, by-product uses are being found for these materials. The canning industry is so concentrated in Florida that half of the peel is available for processing, and from it has been manufactured, since 1933, an amber-colored oil which smells like orange or lemon oils and equals them as a flavoring agent. Most of it goes to England to be used in beverages.

A more recent and interesting development is quite in keeping with the name: The grapefruit is called grapefruit because it frequently grows in large clusters, like grapes, and like grapes it is now being used as a source of wines, brandies, and cordials. Grapefruit champagne has already seen action at a public function at Washington where President Roosevelt indulged. Oranges are similarly utilized, and wines from these two fruits cannot be distinguished, although they both possess a flavor distinct from that of grape wines. In either case, sugar must be added, a legal and necessary process, for these citrus fruits do not contain enough natural sugars to ferment properly. In the grapefruit, total sugars run from five to eight per cent; the orange has up to 12.6%; while grapes contain from 12% to 25% sugar. High acid content in the citrus fruits is also a drawback, dry wines being excessively sour. The juice from which the wine is made is obtained from sound fruit, which is of unmarketable size or color or has been frozen, by cutting them in half and reaming on revolving burrs. Care must be taken to exclude the naringin which gives a bitter product. It has been found that baking the wine for two months at a temperature of about 125 degrees F. imparts to it a sherrylike flavor. Citrus spirits and cordials are made from the wines by the usual methods.

Although the process has been commercialized for only a few months, the five citrus wineries in Florida already have a capacity of about 20,000 gallons a year. When it is remembered that France, with half our population, has 7,000,000 people employed in her wine industry, this new venture appears to have a limitless future. However, Frenchmen haven't the American's indifference to wine.

* The bitterness of peel and membrane is caused by a glucoside called naringin, which is believed to have some therapeutic power (because of its bad taste?) and is more bitter than quinine; one part in 50,000 parts of water can be detected.



*Bureau of Reclamation*

DRAGLINE

***Framed by giant cactus, this dragline is shown at work on the main canal of the Gila Federal reclamation project in Southwestern Arizona. The Gila project taps the Colorado River where its flow is regulated near Yuma below Boulder Dam, and the main canal will irrigate 150,000 acres***

## *On the Architectural Front*

EARLY in this winter of 1937 one hears the steam shovels, harbingers of another building spring, snorting like bulldogs on every unoccupied corner. That the building flood is mustering its waters is clear enough from both statistical and visual evidence; that it will reach spate in the coming season seems likely. It is fun to speculate on what sort of *débris* this latest flood will leave in its wake — to guess what we may expect our architects to do with the power to beautify that is so shortly to be placed in their hands. Will their work be eclectic — will it be modern?

In guiding to a decision there are a few facts and also some rather weighty straws. Primary fact is perhaps the Oregon State Capitol Competition. Here is a community to house the capitol which, unlike Washington,

FISH-EYE VIEWS

*Ely Cathedral, Cambridgeshire* (left), *and Trafalgar Square, London* (right), *photographed with the Robin Hill Fish-eye lens. Mr. Hill's horizon camera, developed for meteorological use, makes it possible to photograph the entire sky from zenith to horizon with a single exposure*

imposes no environmental limitations on the designer of a new major building. Under such circumstances a Bertram Grosvenor Goodhue was able to develop, for Nebraska, a capitol which was in the true sense of the word modern, and which, without stretching fact to exaggeration, was also timeless. Were the results of the Oregon competition as happy?

To the competition were summoned many famous names. That they were mostly of the older generation, mostly academicians, does not matter, for they might have served with their eclectic approach merely as a better foil for the scintillation of the few modern-minded men who also were invited to compete. These moderns with unanimity recognized the bicameral nature of legislative function and adopted this, together with the separation of executive and legislative powers, as the themes of their designs. They were snowed under in the voting. If their hypothesis were to be thrown out the window, it is quite probable that the design chosen as the winner was well chosen. Despite its monitor top, which replaces the conventional dome, despite the fact that the building says neither that it is Oregonian nor a capitol, the Trowbridge and Livingston opus was first class as compared with the efforts of some other rather well-known designers.

This Oregon competition ran into a good deal of difficulty of one sort and another which it is profitless to rehearse here. The significant facts are, first, that so many distinguished eclecticists could produce such a series of ill-studied designs, resembling nothing different from a series of student renderings on the same subject and, second, that any such building as is going to be built will become Oregon's capitol in the late Thirties of the Twentieth Century.

A casual item that also shows the wind is the fact that after some years of quiet the architects are again bursting forth on the gastronomic front. Just when the architect became the traditional oenophilitic and gastronomic overlord of America is hard to say — probably it all began with Henry Handel Richardson. But the tradition persists. Today actual architectural articles in serious architectural publications are beginning once more to dwell with equal love on *moules au vin blanc* and the friezes of the Parthenon. This comment is no idle remark for *entr'acte* entertainment. Its implications as to the state of architecture as practised by the *boulevardier* are important — they are more important as indicating the sort of wishful thinking about a dead past that still dominates a considerable and active part of the profession.

Finally there is great food for thought in the answers to the many questionnaires recently sponsored by architectural journals. These questionnaires have principally been directed toward architectural education or toward improvement of the profession. They have been circulated among as catholic a group of reasonably well-known architects as the journals could unearth. The response to such questionnaires reveals schism. A Saarinen may point out that "the competency of the profession will increase as it learns to think clearly, and that, I am afraid, will not come until we can start afresh, educating a new generation," but most of those who will control the buildings of the next decade do not agree. Two moderns may speak in what their eclectic fellows will regard as crass language: "The profession can increase the competency of its members if it can make them conscious of their true position in the social order. . . . It is our opinion that the architectural schools are still

*Steiner from Black Star*

ICE FLOWERS
*. . . on St. Moritz Lake, Switzerland*

overwhelmed with a class of medieval sinecurists, walking the straight and narrow path of traditional dogma and looking forward to next summer when they can go to Europe and make bad water-color sketches." Others find all cheery and bright and right with the world, affirming with omnipresent human consolation that everything is all right and getting better; while others make this or that tiny suggestion for improvement of some minor detail and all condemn group practise such as that of Tekton.

It would probably be otherwise if the younger generation could have its say, but the actual fact is that there is precious little of the younger generation in architecture. Even without the depression, the course of modern architectural practise in this country has been such as to retard the development of youth. The depression has practically eliminated the young architect from the profession. A few have found fortunate berths and will be ready to contribute for the next decade. Many have managed to keep alive and will now come thronging back to the boards they left as many as eight years ago. The most virile, most brilliant of this depression generation, however, will have been dissatisfied with such a Fabian policy and, as fact proves clearly enough, have found success elsewhere. It will be pretty hard now to draw back to strict architecture such men as Sidney B. Waugh, '27, William E. Muschenheim, '25, or Theodor C. Müller, '26, to name only three young men of Technology. Architecture always has and always should spill over into the allied crafts of sculpture, interior decoration, and industrial design, but when the pitcher is tipped upside down, architecture cannot expect to reverse it and find much valuable liquid left in the bottom.

This means, in total, that for the next decade the brilliant potentials of the last decade in the main may not exert force on our architecture. These potentials were probably largely modern. Any tendency to modernism from this source is therefore considerably diluted.

The Review has no position to take with respect to the relative merits of modern and eclectic architecture. We are concerned here only with what is likely to happen, and, as a result of the factors discussed, it is quite possible to foresee almost no modern architecture during the building boom, perhaps less than during the depression when some not-too-sincere modernists felt it necessary to startle the world.

In houses Americans definitely do not want modernism. For that matter, few Europeans do either. A *Tugendhaus* makes one waver in favor of the modern house, but it requires greater genius to produce a good *Tugendhaus* than it does to produce a good Georgian reproduction. The reproduction is easier to sell and for most domestic functions more comfortable, to boot. The operative builder is no dolt and he is not found building modern houses in his new developments. The fact is that there are few places in the house where organic logic produces a much better result than unorganized sentiment will. The hearth is a poor place on which to try to brew logic, as followers of other professions than architecture have found and will continue to find out.

In larger buildings the case is otherwise, but the results will not be. A library, for example, is a place to store and use books. As such the first functions are to keep the books in good condition, to make them readily accessible, and to provide proper places for using them. None of these has any relation to the disposition of niches in a Pantheon or to the orderly fenestration of an Early American town hall. It should be possible to start with the needed plan and fenestration, and by some small compromise arrive at the necessary external beauty. That is what the young men of the past decade might have done; it is hard to guess that the old men of the next decade will do it.

It will be possible, however, to watch one development of this sort. If Congress accepts the Mellon gift in the spirit in which it is offered, the new Mellon gallery,

*Fairbanks*

*This graceful arch has been designed for a unit in Mussolini's beautification of Rome*

the design of which has been intrusted to John Russell Pope, may well be a test tube. The collection is magnificent and must be housed in such a way that the pictures may be well seen. At the same time it will be in a building which must befit the predominantly Greco-Roman surroundings. Mr. Pope has shown his ability to cope with such a problem before without too much compromise. It will be possible again.

One final comment may not be amiss in ending a long prediction. At first glance the designs for the New York World's Fair competition stand in refreshing contrast to those for Oregon's capitol. This is due only in part to the fact that more young men were invited, for eclecticists and moderns alike contributed a stimulating group of designs all of which had enthusiasm and interest. This might be taken as encouragement if it were not for a rather awful counterthought: Is not the reason for this ebullience the fact that the buildings are of less permanent nature? Is the architect of today really capable of brilliant flowering but held back by cerebration when buildings that he views as important and permanent are in question? It seems so. This is most unfortunate, if true. It is the "unbuttoned joy" of a Beethoven that counts in the long run, far beyond the pedantry of a Respighi with greater musical training. To the answer that one should not indulge in unbuttoned joy with his client's money the apt riposte is that the great manages to have his fling while leaving the client something worth while. However this may be, all the signs are that modernism, as it has come from Europe, seems unlikely to flower much under the burning sun of the coming boom. Let this be consolation to those to whom it thus serves.

## *Tides in the Atmosphere*

THIRTY miles up, the atmosphere is boiling hot, and swings in tremendous tides 12 hours apart, which are completely out of step with similar swings in the lower atmosphere. These are the conclusions reached by Dr. Chaim L. Pekeris, '29, Research Associate in the Institute's Department of Geology, through a recent inquiry into atmospheric tides. Dr. Pekeris' investigation not only reconciles several previously contradictory atmospheric phenomena, but also contributes further evidence of extremely high temperatures in the upper atmosphere.

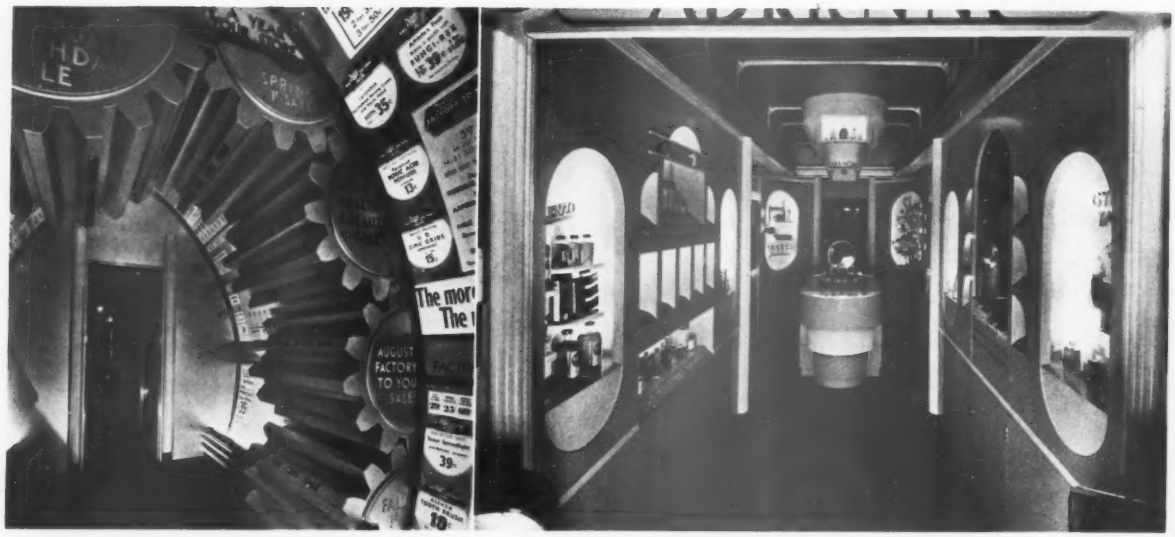
Since in our latitudes irregular changes in the weather completely obscure the small regular semidiurnal variations in the barometer, the fact that these tides exist in the atmosphere just as they do in the ocean is not generally known. In the tropics, however, the tides can be indirectly observed because of the fact that more stable weather conditions permit the barometer to register two persistent peaks, one at about ten o'clock in the morning and the other, ten at night, with equally persistent lows at four o'clock in the morning and four in the afternoon. The striking feature of these tides is that they occur regularly at the same hours, and thus appear to follow the sun and not the moon.

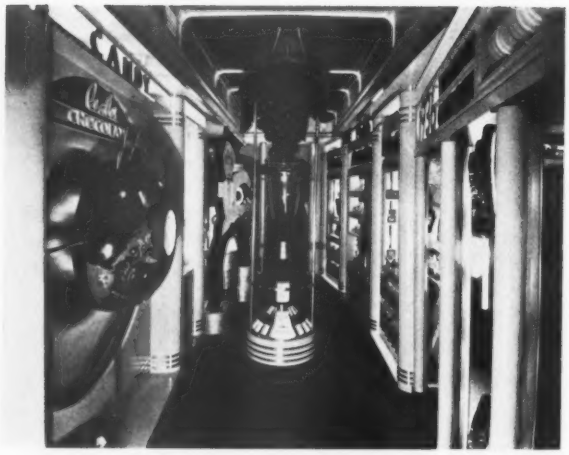
The sun's dominance, however, is puzzling in view of the fact that the moon, so much closer to the earth, exerts a tidal pull more than twice as great as that of the sun. The anomaly involved here led the French mathematician and astronomer, Laplace, to decide in 1774 that the barometric variation is brought about by the sun's heating the atmosphere — a theory called in question a century later by Lord Kelvin, who pointed out that heating by the sun would lead to a diurnal rather than a semidiurnal tide. Kelvin set up a theory that the atmosphere can swing freely with a period very close to 12 solar hours, so that the tidal action of the sun is magnified by resonance. In accordance with this theory, the atmosphere is thought to act like a tuned radio receiver, picking up one station — the sun — and being insensitive to the other — the moon. The tuning of the atmosphere, however, has to be rather sharp because the lunar day is only about an hour longer than the solar day. Recently, moreover, Professor S. Chapman of London showed that the atmosphere actually does pick up, even though very weakly, the tidal action of the moon as well as some other waves of different periods. These additional barometric waves would be expected to exist, however, in an atmosphere having a fundamental free period of 12 hours.

These observations complicated the problem by contradicting other observations which indicated that the free period of the atmosphere is not 12 but 10½ hours, a length reported in 1929 by Major G. I. Taylor, a professor of the Royal Society of London and a prominent yachtsman. The pressure wave which was caused by the great Krakatao eruption of 1883 and which went around the world several times propagated itself at a speed characteristic of an atmosphere (*Concluded on page 174*)

Rittase

*"Thirty miles up the atmosphere is boiling hot and swings in tremendous tides . . ."*





## ENGINEERING APPLIED TO SELLING

Instead of asking their agents to travel to a convention, the United Drug Company last year decided to take the convention to their agents. Moving the mountain to Mohammed was an engineering, as well as a selling problem, and United Drug turned it over to a large group of engineers, salesmen, artists, and designers. The result was the Rexall train complete with four exhibition cars (in which the adjacent pictures were taken), two lecture cars (which also served for dancing and motion pictures), air conditioning, independent lighting plant, phone service, and a *Commodore Vanderbilt*-type steam locomotive.

The train, exhibiting 8,000 products, traveled 29,000 miles, stopped within 100 miles of every Rexall agent in the country, drew visitors totaling 2,360,001. One of the exhibition cars was a complete drug store with mirrors the whole length of one side to create the illusion of a store twice as wide as the nine-foot width of the car. The exhibits, which set a new high in display technique, were designed by Architect Nelson C. Chase, '17, with the collaboration of A. W. K. Billings, Jr., '26. The general sales manager who conceived this rolling convention and guided its successful tour was trained, it is significant to note, first as an engineer, next as an artist, and finally as a salesman.

# The Future of Invention

## *Incentives to Discovery Must Be Maintained!*

By Robert E. Wilson

PROBABLY the most audacious task the human mind ever undertakes is attempting to predict what the human mind will ultimately accomplish. This is particularly true of attempting to predict what will be done by inventors — those peculiar but invaluable individuals whose principal assets are a healthy dissatisfaction with things as they are and an incurable optimism as to the possibilities of improvement. However, history has shown and I think that even the pessimistic prophets of the past, were they living today, would concede that the only gross error which could be made in such a prediction would be to underestimate the infinite possibilities of the human mind in the fields of research and invention.

In considering the probable future of invention, consideration should first be given to the rapid changes which have been taking place in the field of invention during the past few decades. Any such study reveals a number of very definite trends. We used to consider the typical invention to be a mechanical contraption put together by some ingenious individual to meet some definite need. Necessity was the mother and mechanical ingenuity the father of such inventions. Today a very brief study of patents granted or of any publication dealing with inventions indicates that the typical invention of the present is a complicated electrical device or chemical reaction which has been worked out in some well-equipped laboratory. Invention has now grown up and is more often the mother than the child of necessity, as witness the hundreds of new products trying to convince the world that it needs them.

The trend of invention today is unquestionably from the empiric toward the theoretical, from the amateur or occasional inventor to the professional, from the accidental toward the deliberate and sure, and from the individual to the organized inventing group. A consequence of these trends is a prodigious increase in both the rate and efficiency of invention and a tremendous enlargement of the field in which future inventions can and will be made. It does not mean that the day of the free-lance inventor is past — indeed the tendency for the most far-reaching inventions in any industry to come from those outside still continues — but it does mean that if the free lance is reasonably to anticipate success today he must, in addition to possessing the traditional traits of the inventor, have a thorough scientific training, proper equipment, and a well-conceived plan of attack.

Other interesting changes are taking place as a result of this shift in the general character of the process of invention. The distinction between discovery and invention, which was formerly rather clear-cut, has practically disappeared; thus a chemist searching for an effective catalysis or a new product has made an invention as soon as he makes the sought-for discovery. Many of the most far-reaching discoveries and inventions of today are made by men who are not trying to invent but merely endeavoring to satisfy their scientific curiosity or explain some peculiar phenomenon. In the older field of invention the development of a highly satisfactory article generally left just one less thing to invent. In the newer field every new discovery or invention is simply a stepping stone to dozens of others with no limit in sight in the expanding horizon of science.

In discussing the probable future of invention with a number of workers in different fields I have been struck by a rather sharp divergence of opinion between men of equal ability. In general it appears that the men who are engaged in applied research in the older industries where operating costs are low and investments high feel that the quality of invention is declining and that what remains is more or less a "mopping up" process. On the other hand research workers on the outer fringes of science, or in industries where the application of science is relatively new, feel certain that the most important discoveries and inventions are those yet to be made and that the sky is the limit for the future of invention. I am personally convinced that whatever may be the future of research and invention in some particular narrow field or industry, looking at the picture broadly, the business of inventing is inseparable from the tempo of scientific advance and that the only thing which could seriously retard invention is some untoward curb on the development of science. Of course the maximum intensity of invention will continue to shift from field to field as it has in the past. While I feel certain that chemical inventions are to continue for many years their amazing rate of increase, I believe that the particular fields in which the number of important inventions is likely to increase most rapidly during the next century are those of medicine and agriculture, particularly as research in these fields is taken up more and more by highly trained scientific specialists rather than by men trained along conventional medical or agricultural lines. Our agricultural traditions were largely inherited from North Europe, whose climatic conditions differ markedly from ours, and one result has been the loss of a staggering proportion of our topsoil in about a century of such farming. Only extensive and thorough research can stop such loss before it is too late. I firmly believe that in another century our descendants will look back upon the present as merely a part of the dark ages of agriculture and medicine.

Some pessimistic persons who believe that the curve of invention is flattening have pointed to the fact that, in spite of the tremendous increase in the number of scientifically trained men and the number of research workers in this country, the number of patents issued by

the United States Patent Office during the past 50 years has barely kept pace with our increase in population and not at all with the increase in the number of men who are devoting their lives to the attempt to discover new facts and invent new products and processes.

There are three principal explanations for this relatively slow increase in the number of patents: In the first place, the older fields of invention open to the entire population have been pretty well worked out and our newer generations are having little opportunity to develop either mechanical ingenuity or inventive faculties in this push-button age which insists on hiding the working parts of every mechanism. Our scientific workers have had to offset this loss before they could show a net gain. In the second place the standard of invention in our Patent Office today is certainly higher than it was, as should indeed be the case in view of the general advance in knowledge. Third, and probably most important, is the fact that while the type of invention made by the average inventor of the last century was usually related closely enough to our everyday needs to find prompt use and justify patenting, the average discovery or invention made by the scientist today is in a realm which, while ultimately of great importance, is less likely to have actual immediate application or definite cash value within the 17-year life of a patent. Accordingly the tendency is to patent a smaller proportion of the inventions which are being made in the field of science. That the actual pace of scientific discovery and invention is still increasing in geometric ratio is apparent when we note the rate of increase in the number of original scientific articles which have appeared during the same 50-year period. To illustrate: The number of chemical articles and patents abstracted by *Chemical Abstracts*, which has endeavored to cover its field completely, has been, for certain typical years selected at nine-year intervals, roughly as follows: 1908 — 10,800; 1917 — 15,600; 1926 — 29,200; 1935 — 61,800. It will be noted that the abstracts have approximately doubled in each of the last nine-year periods.

From these and many other facts, I feel certain that the process of discovery and invention is still young and vigorous with no limit in sight either as to new facts which can be uncovered by diligent research or new human wants and needs to keep up the demand for invention. However, it needs no Chinese proverb to teach us that trees do not grow to heaven, and even though there is an ever-expanding sphere into which the growth of science can conceivably continue, we cannot overlook the possibility that there may be some inherent weakness in the structure as a whole which will in time retard or even ultimately stop this growth of invention, just as unfavorable climatic conditions, or lack of nourishment from the roots, or attack by outside agents will ultimately stop the growth of a tree. Probably the most interesting aspect of the question of the future of invention to which we can address ourselves today is to attempt to appraise those factors which might tend to retard or limit the growth of science and invention, and consider what we might do to prevent such a disaster.

One such retarding factor to the future of invention is that the proportion of men working on the frontiers of science to develop new facts and principles has lagged far behind the number working on the utilization of these principles and their application to everyday problems. For example, the number of highly trained men working in the field of pure science and doing the real pioneering work is today about the same as ten years ago, while the number of such men in our industrial research laboratories has grown by leaps and bounds. Today it seems probable that on the whole our workers in applied science are living off the fat of prior discoveries, a process which cannot continue indefinitely.

This shift in emphasis has been due first to the rapidly increasing demand from industrial laboratories for better and better trained men at salaries higher than our universities and foundation laboratories can pay. During this same decade the income of our endowed laboratories has on the average declined slightly whereas the money spent on applied research has probably nearly doubled. It will be difficult to reverse this trend because the rate of return on endowment investments seems destined to remain very low, and the prospects for great increases in private endowments, such as marked the post-War period, seem rather gloomy in view of the many expedients which have been developed to prevent the accumulation or transmission of large stores of private capital. Furthermore, in the case of the privately endowed educational institution the shrinkage in income is generally felt with particular emphasis in its research activities, as its educational activities naturally have first call on the available income.

As possible remedies for this situation, there are four which seem worthy of consideration: In the first place, the building up of privately endowed institutions from which so many of our scientific discoveries have come should be encouraged, not only by lower taxation on bequests to such institutions but preferably by lower taxation on the entire estates of men who give a substantial proportion of their inheritance to nonprofit scientific or charitable institutions. Such a change in policy would certainly be in the public interest and should have both popular and political support, once its aim is appreciated.

In the second place, our industrial research laboratories must in the future assume more of the responsibility for seeing that certain fields of pure science bearing upon their industry are investigated from a long-range point of view. A number of our outstanding industrial laboratories have already taken this broad-gauge attitude and are profiting thereby, but it is still difficult to persuade the average industrial concern to permit its research laboratories to carry out investigations for which no immediate use can be described in advance, and the organization of these laboratories is generally not flexible enough to permit men with fertile imaginations to roam beyond the range of the immediate problems which they consider it their duty to attack. The companies which do undertake this type of work will reap increasing rewards as time goes on.

The third possible avenue for restoring the balance between pure and applied research is by governmental aid. It is a rather sad commentary on a civilization which owes so much to science and which could gain so much from further applications of science, that of the billions of dollars spent to relieve unemployment during

the recent depression an almost negligible amount went to the support of any sort of scientific activity, in spite of the specific recommendations to this effect by numerous scientific groups and governmental bodies. It seems an economic crime that thousands of young and well-trained scientists had to work on all sorts of "made-work" projects which made no use of their scientific ability when they would have been overjoyed at an opportunity to utilize their knowledge and acquire experience by working on the many scientific problems which are crying for solution, even on matters closely related to governmental problems, as for example, agriculture, public health, housing, and road building.

However, the unemployment of really well-trained research workers is no longer a major problem and the present question is what the government ought to do to aid and foster fundamental scientific research. The logical answer appears to be to expand and improve the work in pure science carried on in the various government bureaus. It goes without saying that such work must be carried out strictly on the merit system without political influence either in hiring the men or directing their work. Such expenditures would relieve unemployment both directly and indirectly, but the ultimate value to our welfare should be far greater than from any other use to which the money could be put. Our state universities should also see the merit, both from an educational and scientific point of view, of increasing their support of fundamental research, since they have so much talent available for its guidance. The quality of scientific work emanating from many of our Middle Western state universities is certainly a cause for congratulation.

There is one other possible method of financing an increasing amount of scientific work, which should not be overlooked, and that is from the proceeds of the occasional highly profitable commercial invention which may be made in these noncommercial laboratories. In certain fields, particularly in medical research, there is an ethical tradition against the patenting of any scientific discovery bearing upon the health of human beings. However, more and more medical scientists are coming to adopt the broader view that to protect a medical invention from exploitation and insure its prompt availability, it is frequently necessary to take out patents, grant licenses, and charge reasonable royalties, and where such royalties are devoted to the support of further research, preferably in the same general field as that from which the royalties came, the research worker has certainly made a much more lasting and valuable contribution to human welfare than if he should fail to patent and leave the invention to the mercy of the quack and the exploiter. The administration of such patents may have been open to criticism in a few cases, but intelligent control by a qualified board of trustees is certainly preferable to no control, and much productive research has already been financed by this method.

A further threat to the future of invention is the increasing tendency throughout the world toward regimentation and governmental control in every field. Both the Fascist and the Communist *régimes* have made gestures in the direction of fostering research, but when they start as they do by exiling all scientists not in sympathy with the ruling party, destroying academic freedom, and seizing the control (*Continued on page 164*)

*So clear is the water in this photograph that the logs appear to be suspended in air!*

Rittase

**THE BULBOUS NOSE**

*. . . of this French bomber suggests the physiognomy of a prize fighter. A heavyweight it is and cumbersome, but it is said to be an efficient long-range weight carrier. Known as Breguet's* Vultur, *it is produced, as its architecture might imply, in a passenger-carrying version*

# EUROPEAN TRENDS

## *As Disclosed at the 15th Exposition*

BY S. PAUL

FLASHING electric bulbs in gun muzzles and swift bombers pregnant with fish-tailed eggs set the tone of the 1936 Paris Show and reflected the general state of mind of Europe today. Where New York's 1937 Aviation Show is boasting a ten-to-one ratio of civil over military exhibits, the military far and away outnumbered the civil at the Paris Salon.

The influence of technical progress that has marked our own commercial developments was obvious. Most of the big machines fitted into the common twin-engined monoplane formula of our Boeings and Douglases. Except for a few French civil aircraft, all-metal ships were the rule. Flush riveting appears in the ascendancy and a considerable interest was shown in electric spot welding. Controllable-pitch propellers were the rule rather than the exception, with honors about equally divided be-

**LIKE A DEAD TREE**

*. . . to which the buzzards flock, the Paris Salon drew mostly bombers and other military planes. In the immediate foreground above is Britain's Bristol Blenheim bomber; behind it is the newest Amiot. The huge wing in the background belongs to the Farman,* Centaur II, *commercial transport for "Air France"*

**LIKE A WASP**

*. . . with stinger between its hind legs is this latest and unconventional design of Fokker's. It is built for attack, light bombing, and reconnaissance*

MOST RADICAL

*. . . was Koolhoven's fighter, a single-seater with engine (Lorraine U-12) in the middle of the fuselage (behind the pilot) and with twin propellers. Landing gear is completely retractable; lateral control by wing tip slots; expected top speed: 320 miles per hour*

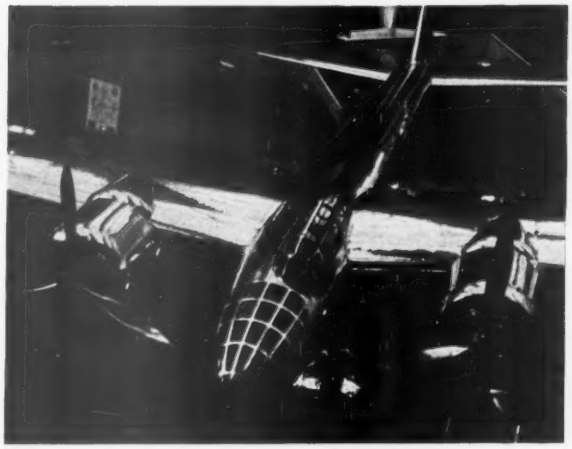
# IN AIRPLANE DESIGN

## *Internationale de L'Aeronautique*

JOHNSTON

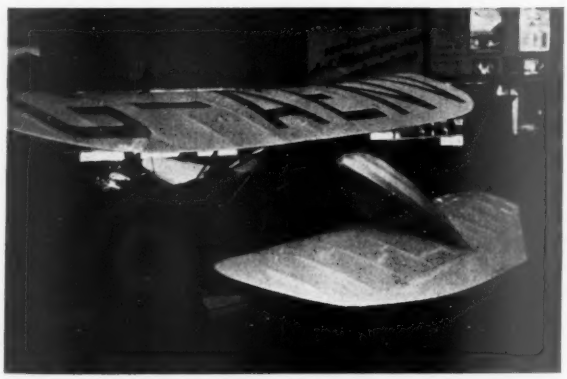
tween the Hamilton Standard hydraulic type, built under license abroad, and the Ratier air and electric-driven types. Curtiss-Wright, only all-American exhibitor, featured a new constant-speed electric controllable.

Propeller brakes, seldom seen in this country, appeared on a surprisingly large number of installations. Engines of the radial air-cooled type predominated, with many 14-cylinder, twin-row types in evidence. United States-developed cowling, with trailing edge flaps for controlled cooling, was almost universal. Few liquid-cooled engines were actually installed in aircraft, but both Rolls-Royce and Hispano-Suiza exhibited large power plants of this type. Outstanding was the Rolls-Royce *Merlin*, said to deliver some 1,065 horse power with 1,318 pounds all-up weight. Only one Diesel, the French *Coatalen*, put in an appearance.



SLEEK AND SHINY

*. . . this beautifully faired Amiot bomber has almost attained the ultimate in "clean design." Note the offset inclosure for the pilot's head, the curved mullions of the windows. There are rumors that cannons are being mounted in planes, may change the whole aspect of aerial warfare*



PERT AND TINY

*. . . is Mignet's Cabin Louse* (Pou-de-Ciel *it is called with entomological inexactitude). Within its narrow confines may be found all the luxury of a coupé*

# Charles Hayden, '90

## (1870-1937)

### *Friend of Youth, Benefactor of Technology*

**HE BEQUEATHED ONE MILLION DOLLARS TO THE INSTITUTE**

Keystone

*"I am firmly convinced," wrote he in his will, "that the future of this nation, and of the world for that matter, depends in no small part on the young men of the United States."*

AT the youthful age of 19," noted *Barron's*, 15 years ago, "there was graduated from the Massachusetts Institute of Technology a fair-haired . . . Boston lad who was destined to play a prominent and creditable part in the world of industry and finance. Indomitable ambition, a clear brain, and a likable personality constituted his assets." This lad whose youthfulness was so distinctive as a Bachelor of Science was the man, still distinguished for his youthfulness, who died on January 8 at the age of 67.

Charles Hayden — "always busy, he looks younger than he is" — himself always young, even as a director of directors sitting on the boards of 72 corporations, preserved after his death his accent on youth by making his largest bequest ($1,000,000) to the Institute and by leaving the bulk of his $50,000,000 fortune to establish a charitable foundation for the education of boys and young men and the "advancement of their moral, mental, and physical well-being."

Mr. Hayden's bequest to the Institute capped a long series of gifts that up to his death already had totaled nearly $700,000. "His interest in the welfare of young men," wrote President Compton last month, "is memorialized at the Institute by the dormitory unit which he contributed and which, by action of the executive committee, bears his name. His interest in his professional training in mining engineering was given material expression in his contribution of a principal portion of the funds used in the construction of the Institute's building devoted to mining and metallurgy. In addition to these major contributions Mr. Hayden was continually and quietly contributing to student needs, as for example in various ways to aid in the development of recreational sports so much needed in an institution of this type where the academic load is severe.

"To all of his Institute colleagues and friends, Mr. Hayden exhibited his impulsively warm and generous disposition, his colorful personality, and that fundamentally sincere devotion to the welfare of young men which is so notably expressed in the terms of his will. Mr. Hayden's generous bequest serves to emphasize the constructive value of his lifelong interest in the institution and the great personal loss suffered in his passing. At the time of his death, he was not only a Life Member of the Corporation of the Institute but was also a member of its finance committee, chairman of its student loan fund committee, and chairman of the Research Associates of M.I.T. To the latter two of these activities Mr. Hayden had been a generous contributor as well as active in their administration."

Despite his extraordinary activity in banking and finance Mr. Hayden found time to participate in many other Institute activities. He was president of the Class of 1890, and his classmates have vivid memories of the enthusiastic part he played in the great Reunion of 1916 when the present buildings of the Institute were dedicated. He made his yacht available for class activities, and at the now famous telephone dinner of 1916 he played a major part in raising $1,500,000 in response to "the mysterious Mr. Smith's" offer to give $2,500,000 if Alumni would contribute $1,500,000 more.

*Mr. Hayden (in white) entertaining classmates on board his yacht during the 1916 Technology Reunion*

In 1925 he became president of the Alumni Association and during his term of office he called a conference between the executive committees of the Corporation and the Association, and from this meeting came the opinion "that more than an auditorium, more than a new gymnasium with swimming pool, more than anything else the two committees could imagine, the Institute needed additional dormitories." The outcome was a drive for money (Mr. Hayden contributed substantially), and an ultimate doubling of the Institute's dormitories (*Concluded on page 170*)

# Science and American Literature

## *A New Bench Mark for Critics*

By Paul C. Eaton and Frederick G. Fassett, Jr.

"American science dashes along at 50, 60 miles an hour; but American literature still lumbers along in the old-fashioned stage-coach at ten miles an hour." — Joaquin Miller, 1902.

VENTURESOMENESS and curiosity, controlled always by a shrewd pragmatism, are conspicuous qualities of the American. It is, therefore, not surprising that they have worked themselves out as the major influences identified thus far in efforts at critical appraisal of American literature. The Puritan tradition, the frontier tradition, the class struggle, and politico-economic determinism are the four main threads with which critics have tried to bind together the three centuries of literary creation in America.

These are, in some senses, mutually exclusive, to the critics' exasperation. But it is conceivable that certain significant expressions of American life may have fallen outside the critics' field of vision. The philosophic individualism and the commercial speculation which sent the Puritans across the Atlantic, later pushed the frontiers westward, and later still were stultified into the class struggle, likewise begot a fifth force which may lessen the critics' trouble in synthesizing the others. This force is science.

Science, as it affects life and so literature, is either the quest for truth stripped of anthropomorphic considerations or, in its engineering phase, the manipulation of combinations of mensurable fact for an economic motive. At the one extreme, it is profoundly philosophic, questioning the bases and justification of life itself. At the other, it permeates the existence of every man, surrounding, amusing, and often harassing him with tangible material objects; raising to the thousandth power his range of communication, and so cutting down insularity and independence at the same time; and increasing the speed of all things to such an extent that the superlatives no longer can express it.

Any measurable social factor works as an influence on literature in two ways: subjectively on the author as part of his social and intellectual *milieu;* objectively both as it affects the mass of idea, character, and setting from which he draws his material, and as it conditions the time and taste of those for whom he must write, and upon whom his existence therefore depends. Both the philosophic and the material aspects of science have affected literature in each of these ways.

The development of American national culture is peculiar among the cultures of the civilized world in that the bulk of it occurred during the period of greatest scientific advance. Even today, no other civilized man is affected so often and so variously in his daily life by science as is the American. It is the more regrettable, therefore, that the coincidence and the correlation of the development of science and of American literature should have been hidden so thoroughly from critical attention by forces which at different times have been dominant.

From the Colonial period down through to the most modern of contemporary literature, the new terminology which science has applied to man's quest for truth has become an increasingly conscious concern of the reflective spirit. Deliberately, many a creative mind has sought to help the average man resolve the doubts which this terminology has raised in his soul. The sweep of the subjective influence of engineering upon authors may be measured by the distance from the quill pen to the dictaphone, with all that it implies. The material aspect of science, too, is at work subjectively upon the literary artist when he makes a sincere effort to assimilate to literature a body of new material which science puts before him; such efforts were made in America before Hawthorne wrote "The Celestial Railroad," and the end is not yet. Objectively, the fourth aspect of science brings about a new popular demand nearly every week; in literature, the least result of these demands has been the creation of an entire new school, that of the pulp magazine.

In its earliest manifestations in American life, science was not productive of objective and immediately measurable social results. Here, as in Europe, scientific pursuits during those earliest decades were essentially the amusement and recreation of ingenious minds. The creation of literature was likewise in the main confined to such minds. It is significant that both Cotton Mather, the Puritan divine, and William Byrd, the Virginia cavalier, were carrying on scientific investigation and speculation as an adjunct to the writing of sermons and the managing of estates. Mather's activity in the smallpox inoculation controversies of his time needs no elaboration; his reports to the Royal Society, of which he was a member, are, however, much less well known. Byrd recorded with accuracy his observations on the geology, topography, and meteorology of a hitherto unexplored region. The fact of recording is important in itself. But more important is the fact that these records, made even with little or no thought of publication, evidence the personal interest in things scientific which was held by a family aristocratic at once socially and intellectually.

The obvious early example of our thesis, of course, is Benjamin Franklin. Enough has been said to suggest that he was not at all the isolated figure he often appears, but because of both his own personal fame and the spectacular nature of some of his experiments, he was of especial importance. His work served in large measure to crystallize latent interest in science both here and in the Old World and, thus, to bring science as a core of

thinking to the forefront of creative and, consequently, literary minds wherever they were. With him, moreover, there ends the period of primarily speculative or recreational interest and begins a period of applied interest which was to have its greatest impact in the form of engineering. Franklin's lightning rods were arrows pointing toward the airplane. Franklin, too, was about at the last of the age in which science was the preoccupation of a relatively small group of scholarly minds, and about at the beginning of the new age of wider and wider popular interest.

The first century of this new age was engrossed in the mastering and exploitation of a continent. Fortunately for Americans of the present, the beginning of this period of exploration and exploitation nearly coincided with the beginning of a period of the greatest inventive activity in history, and of the application of science to material ends. Thus was enabled the performance in a century of a task which otherwise might still be incomplete; thus also was the literature of the frontier made possible and implemented with many results of science ranging from the Colt's revolver to barbed wire. Obviously, the main preoccupation of the American mind during this time was an engineering preoccupation. Nevertheless, interest in the speculative and philosophic phase of science continued, somewhat apart from and subordinate to the main stream. It is significant that the two American authors of the time whose main interest was in this temporarily secondary phase are the two whom it is hardest to integrate into American literature as a body — Poe and Hawthorne.

These men, thus insulated from the main current of engineering, seem equally to have isolated themselves from the important in the life of their time. But this appearance is false. It will not do to dismiss Hawthorne thus summarily because the period of exploitation did not stir him, because the Civil War, for instance, left him practically unruffled. It is entirely likely that this inheritor, philosophically, of Jonathan Edwards was drawn to that phase of scientific interest which will in the ultimate prove to be of the greatest importance to humankind. In him, the ethical and moral sense of the Puritan warns against the penalties which may be imposed upon interference with a closed natural system. "Rappaccini's Daughter" and "Dr. Heidigger's Experiment" are in a sense anticipations of O'Neill's "Dynamo." Poe, like Brockden Brown, failing often to distinguish science from pseudoscience, found in phrenology, mesmerism, and illuminism exploitable literary material. That the bulk of Poe's work was in the arabesque and the bulk of Hawthorne's in the romantic past may in part be explained by the fact that they were repelled by the immediate material and engineering preoccupations of their era.

When the continent had been mastered and the pioneering spirit had no longer any open spaces to contend with, it perforce turned back upon itself, and there commenced the still continuing period of industrialization and urbanization which has precipitated in America the class struggle, at once the oldest and the newest phenomenon which men of letters have endeavored to treat. It is with this latter — and in many important elements scientific — frontier that Dreiser, Sinclair, Frank Norris, for example, have to deal. The class struggle as these men have depicted it in their novels is essentially a clash between him who has power and them who have it not. In the novels themselves, the fundamental power must often be obscured because it is presented in terms of economic control, of entrenched wealth, of corrupt union leaders, or of cynical wielders of financial monopoly. But starting with whatever term the author has used, it is a short step to the origin of the power in the machine and the idea which engendered it. That idea sprang from science.

While minds developed in this period were concerning themselves with the plight of their fellows caught between the battle lines of those who controlled and those who were controlled by the tools of production, other minds pondered in seclusion upon the meaning of it. Their efforts at a philosophic synthesis appear in works as widely divergent as those of Henry Adams and Mark Twain.

So much has been written about the impact of Darwin's hypothesis upon Arnold, Browning, Clough, and Tennyson that its effect on American thought as reflected in literature has been obscured. Nowhere in "In Memoriam" nor in "Dover Beach" is there such utter hopelessness as is to be found in the little-read "Mysterious Stranger" or in "What is Man?". Mark Twain's frontier armor and inherited Calvinism were not proof against the implications of evolution. Twain was not equipped to cope with the idea on the philosophic plane; robbed in his later years of the boisterousness and the bluster of the Mississippi and the gold camps, and hampered by the fact that he had a reputation as a humorist, he was forced into futility by the attack of science upon his traditional system of belief.

In the somewhat rarer intellectual atmosphere of the Puritan tradition and Harvard College, Henry Adams had little better fortune when, as a result of the St. Louis Exposition, he tried to assimilate science to an accepted scheme of faith. Adams' strategy was first a retreat into the Middle Ages and then a frontal attack, which was blocked not by his incapacity but by the fact that any efforts to set up a philosophic pattern comprehending both the Virgin and the Dynamo must have been nullified by the closed system of physics, the limits of physical knowledge, of his time. He should have had opportunity to write in the light of later research. The optimism which had appeared earlier in Emerson reached its frustration in Adams, much as the scientific flight from science of Thoreau was counterbalanced by the hearty but unscientific acceptance of it by Whitman.

Connecting the American literature of the present day with that of the two centuries before the World War has been, for those who have attempted to do so in terms of any one of the four accepted influences, a difficult task. There is little enough of the Puritan in John Dos Passos or in Theodore Dreiser, of the class struggle in James Branch Cabell, of the frontier in Edna St. Vincent Millay, of the politico-economic in Ernest Hemingway. But the work of these and of nearly everyone else who has written in America since the debauching of science by economics and imperialism from 1914 to 1918 is positively or negatively charged by contact with science. The cutback and flashback (*Concluded on page 169*)

# THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

## *House of Tomorrow—On Alumni Day*

ALUMNI Day's center of gravity last year was a conference on transportation; this year one of the bold-face items on the program will be a conference on, or better, a preview of, the house of tomorrow — its financing, its materials and architecture, and its neighborhood. Last year's transportation fest drew bigwigs as speakers, attracted many alert Alumni who found it an opportunity to inform themselves about a major factor in American life, and produced pronounced ripples of attention throughout the country as shown by requests requiring the reprinting of ten thousand copies of papers presented.

The housing preview on June 7 (the date of Alumni Day this year) bids fair to be a bigger smash hit than last year's transportation show. Shelter is of vital and intimate interest to every one; we all are anxious to hear how engineering is going to affect the hearthstone, how city planning is progressing in providing our children with a healthy, less dangerous environment, and whether large-scale housing, with or without government aid, is to show in coming years any genuine progress in obliterating those slum areas that, like cancer-mangled faces, the sensitive person shudders to see and wishes to cure.

All of these points the committee is planning to cover, and in the next issue of The Review we hope to announce the actual speakers. There is in this program an unparalleled opportunity, by taking engineering into homes and homes into the laboratory, to stage one of the most attractive and important conferences ever held at the Institute.

## *High-Pitched Research*

PLANS for a comprehensive joint research program to be carried on in a unique laboratory which has just been completed on the peak of Mount Evans in Colorado were discussed by President Compton and Dr. David Shaw Duncan, Chancellor of the University of Denver, at a meeting last month in Cambridge.

The new laboratory, which stands (see adjacent picture) at an elevation of 14,265 feet, is a joint undertaking of the two institutions. It will be used for cosmic-ray research, meteorological investigations, and studies of the biological and physiological effects of high altitudes. In addition to its use by scientists from the Institute and the University of Denver, it is hoped to make the laboratory available when possible to other scientists who may wish to utilize it for special problems.

The laboratory was erected on the peak of Mount Evans after fabrication in sections in Denver and transportation piece by piece to the mountaintop. It is completely sheathed in copper and was especially constructed to facilitate cosmic-ray research. Unusual precautions were taken to anchor the building to its rocky foundations because of the terrific storms which break about the peak at all seasons of the year.

It was to this spot on Mount Evans that Professor Ralph D. Bennett of the Department of Electrical Engineering and a group of research assistants went in the autumn of 1935 for preliminary observations of cosmic-ray intensity at this high altitude. Their studies were carried on for several weeks in the face of blizzards, violent electrical storms, and rapid changes in temperature.

Professor Bennett, who has been coöperating with Dr. Arthur H. Compton of the University of Chicago in the design of cosmic-ray recording meters, expects to install one of the instruments in the Mount Evans laboratory next year to study unexplained peculiarities of cosmic rays.

Meantime, the installation of cosmic-ray meters at various world-wide stations is continuing. Last month Dr. Manuel S. Vallarta, '21, of the Department of Physics left for Mexico to join Dr. Arthur H. Compton, who is there to supervise the installation of one of the self-recording meters at a high mountain observatory in that country.

## *The Corporation Grows*

LAST summer, by a change in its by-laws, the Corporation empowered itself to add to its 35 Life Members and 15 Alumni Term Members five special

MOUNTAINTOP LABORATORY

*On the peak of Mount Evans in Colorado at an altitude of 14,265 feet, M.I.T. and the University of Denver have built, as related on this page this copper-sheathed laboratory for joint research on cosmic radiation and the biological effects of high altitudes*

*The four illustrations on this and the opposite page are successive high-speed photographic studies of the rolling of strip steel. Made for the Bethlehem Steel Company, these studies are another example of the versatility of the Institute's high-speed photographic technique*

term members.* At its meeting on January 6, the Institute's governing body declared these five new seats filled, named as their holders: Edmund C. Mayo, President, Gorham Manufacturing Company, Providence, R. I.; Gordon S. Rentschler, President, National City Bank of New York; Ralph E. Flanders, President, Jones and Lamson Machine Company, Springfield, Vt.; Frank D. Comerford, President, Edison Electric Illuminating Company, Boston, Mass.; and Halfdan Lee, President, Eastern Gas and Fuel Associates, Boston.

Mr. Mayo is a native of Virginia and was graduated in mechanical engineering from the University of Maryland in 1904. He has been president and general manager of the Gorham Manufacturing Company since 1925. Mr. Rentschler was born at Hamilton, Ohio, and was graduated from Princeton in 1907. In addition to his position as president of the National City Bank of New York, he is a director and trustee of numerous banking and manufacturing companies. Mr. Flanders is a native of Barnet, Vt., and holds honorary degrees from Dartmouth, Stevens Institute of Technology, Middlebury College, Rose Polytechnic Institute, Brooklyn Polytechnic Institute, and the University of Vermont. He has been president of Jones and Lamson Machine Company of Springfield, Vt., since 1933.

Mr. Comerford was born in Worcester, Mass., and was graduated from Holy Cross in 1914. He holds honorary degrees from his own college and Harvard University. In addition to being president of the Edison Electric Illuminating Company, he is also president of Charles H. Tenney Company, and chairman of the boards of the Worcester Electric Light Company and the New England Power Association. Mr. Lee is a native of Norway, and was graduated as a mechanical engineer from the *Ilmenau Politechnicum* in Germany in 1908. In addition to the presidency of the Eastern Gas and Fuel Associates, he is a director of the First National Bank of Boston, the Koppers Gas and Coke Company, and the Montreal Coke and Manufacturing Company.

## *$1,491,478*

AT the same Corporation meeting on January 6 at which the new term members were elected Treasurer Horace S. Ford announced that gifts received by the Institute since July 1 amount to $491,478, of which $335,478 is for general and miscellaneous purposes, while $156,000 represents additional donations to the Technology Loan Fund. Add to these gifts the Hayden bequest (see page 152) and the total for the fiscal year mounts to $1,491,478.

*The change in by-laws in no way affects the annual nomination of three term members by the Alumni Association.

## *First Quarter Million Back*

INCLUDING loans authorized for the second term, borrowings from the Technology Loan Fund (see above), established in 1930, now total over $1,000,000. Particularly gratifying to the board charged with the operation of the Fund, however, is the fact that repayments on principal up to January 16 last were $250,003.62. This figure represented nearly 80% of the amount due for repayment and, with improved conditions in industry, this ratio will be expected to rise steadily during 1937.

Under the liberal provisions of the Fund, a man is expected to repay at the rate of $50 every six months

following graduation, but this 80% showing is especially noteworthy in that all of the obligations so far due for repayment have been those of members of the classes not more than five years out of the Institute. Interest is being repaid regularly on the majority of the unpaid notes, and these are considered as extended obligations. It is anticipated that the ultimate collection ratio will be at least 95% of the loans made. Interest received (at the rate of two per cent) up to December 31 last totaled $55,192.20, which was over three times the unpaid matured obligations upon which extensions had not been granted.

Up to January 16, 1,587 had borrowed from the Fund, and 294 of these had entirely repaid their loans. Many debtors are finding it increasingly possible to make payments in advance, and over $11,000 of such payments have been received since the close of the fiscal year on June 30 last. It is also of interest to note that loans made have dropped from the peaks of $202,835 in 1933–1934 and $203,780 in 1932–1933 to an estimated figure of $114,000 for 1936–1937. With the coincident rise in the volume of repayments, it is assumed that during 1936–1937 they will be greater than the estimated outgo of $114,000. Thus in the sixth year of operation the Fund may be said to be revolving.

## *Military Science*

UNDER a change in faculty rules which becomes effective next September for a trial period of two years, conscientious objectors, whose reasons for desiring to be exempt from compulsory military training at the Institute are approved by the Faculty, may substitute certain other studies.

The Institute has required military training since its establishment more than 70 years ago and, in common with the experience of other educational institutions, there have been occasional protests from individual students. The questionableness of compelling conscientious objectors to take military science as a requirement for a degree has been under consideration for some time. As a result, it was decided last month that students whose objections are based on sincere religious or moral grounds should have the opportunity to take subjects other than military science.

Although the alternative requirements have not yet been decided, it is probable that they will include such studies as international law, history of arbitration, or diplomacy, chosen with the approval of a committee of specialists who would set examinations in the various subjects at the end of the first and second years.

## *Electron Apotheosized*

EACH year during the Christmas holidays a year's work in science is brought to focus by the annual meeting of the "Triple-A. S.," the American Association for the Advancement of Science. Last December, at its opening dinner in Atlantic City, this great congress of science heard Dr. Compton, President of the Institute, deliver his valedictory as president of the Association. Fifty years ago the subject of Dr. Compton's address would have been unintelligible because it was unknown; today it makes possible a business totaling hundreds of millions of dollars. His subject: The Electron.

Said he: "The history of science abounds with instances when a new concept or discovery has led to tremendous advances into vast new fields of knowledge

and art whose very existence had hitherto been unsuspected. The discoveries of Galileo, Faraday, and Pasteur are such instances. But, to my notion, no such instance has been so dramatic as the discovery of the electron, the tiniest thing in the universe, which within one generation has transformed a stagnant science of physics, a descriptive science of chemistry, and a sterile science of astronomy into dynamically developing sciences fraught with intellectual adventure, interrelating interpretations, and practical values.

"I take particular pleasure in mentioning these practical values, for even the most unimaginative and short-sighted, hard-headed, 'practical' business man is forced to admit the justification for the pure research — of no preconceived practical use whatsoever in the minds of those who led in its prosecution and of all degrees of success and significance — which has been directed at the electron. For out of this research have come the following things which all can understand and appreciate: a growing business in manufacture of electronic devices which now amounts to fifty million dollars a year in America alone; a total business of some hundreds of millions of dollars a year which is made possible by these electronic devices; innumerable aids to health, safety, and convenience; and an immense advance in our knowledge of the universe in which we live.

"In science, as in human affairs, great events do not occur without a background of development. The electron had an ancestry which can be traced back through the centuries. Its immediate progenitors were the electromagnetic theory of light, spectroscopy, and the leakage of electricity through gases. First cousins were x-rays and radioactivity and the quantum theory, for, out of a background of long investigation of bewildering and apparently unrelated phenomena, there burst upon the scientific world the x-ray in 1895, radioactivity in 1896, and the electron in 1897 — all while investigators in the older fields of heat radiation and thermodynamics were finding those bothersome inconsistencies in these hitherto respectable subjects which led to that unexpected extension of Newtonian mechanics which we now call quantum mechanics. The concept of the electron, behaving according to the laws of quantum mechanics, is now the basis of most of our interpretation of all that falls under the good old name of natural philosophy."

Dr. Compton then traced the long and complex investigations which finally resulted in identification of the electron and the beginning of its amazing career of usefulness as a servant of man. In his discussion of its social significance, which he characterized as its useful applications, Dr. Compton said: "The first of these was Edison's invention of a thermionic rectifier, based on his discovery that negative electricity would flow across a vacuum from a hot filament to an adjacent electrode but would not flow in the opposite direction. This was some years before the electron was discovered as the responsible agent in this phenomenon. But within a few years after the discovery of the electron, Fleming had shown that this same device will operate to rectify radio wave impulses and thus permit their detection with a sensitive direct-current instrument. From this was patented the Fleming valve.

"Once the basic character of thermionic emission was understood and spurred on by the opportunities opening up in the radio field, new inventions, improvements, and applications of thermionic devices came rapidly. Of major importance was the three-electrode tube amplifier of De Forest. Industrial research laboratories in the communications and electric manufacturing business took the lead in developing techniques and

in penetrating scientific exploration. Noteworthy were the vacuum techniques and the monomolecular layers of activating materials developed by Langmuir and the high-vacuum thermionic x-ray tube of Coolidge. In the Bell Laboratories, oxide-coated filament tubes of good performance were developed and applied particularly to use in long-distance telephony. . . .

"Then, mostly within ten years or so, has come an active introduction of thermionic devices which are not highly evacuated but operate with supplementary action of intense ionization of the gas in the tube. First of these were the low-voltage arc rectifiers, like the Tungar. Most interesting and versatile are the Thyratrons, which permit easy control of powerful currents and machinery, and which give a new means of converting alternating into direct current, or vice versa. In this group also are some of the new types of lamps, of high efficiency or special color.

"Not so striking but equally interesting have been the useful applications of the photoelectric effect. First was the use of sensitive photoelectric cells to replace the eye or photographic plate in astronomical telescopes. Then came sunshine meters, devices to open doors or count people or sort merchandise automatically or to register the speed and license number of the unwary autoist. Most important thus far are the current-producing mechanisms in the sound-movie apparatus and in television equipment.

"While, commercially, radio, sound movies, and long-distance telephony are at present of greatest importance, of no less importance, especially to us as scientists, are the marvelous tools which have been put into our hands for further research in practically every field of science — from physics and chemistry to psychology and criminology.

"So we see how, within one generation, the electron has been discovered and examined, with its aid our intellectual outlook upon the universe has expanded in content and been simplified in basic concept, and in its use mankind has the most versatile tool ever put to use. The end of the story is far from told. Every fact or relationship of the electron appears fuzzy with uncertainties when closely examined, for it can truly be said that every discovery discloses a dozen new problems. The field of practical and commercial uses of electronic devices is certainly still largely in its early stages of exploration.

"This story illustrates in vivid manner a number of characteristics of scientific work, some of which I shall simply enumerate: (1) Progress comes by spurts of advance as some big new idea opens up new territory, alternating with periods of consolidation; (2) progress comes not by revolution or discarding of past knowledge and experience but is built upon past experience and is its natural extension once the vision from new vantage points is secured; (3) there is nothing so practical in its values as accurate knowledge, and the pursuit of such knowledge has been most successful when not fettered with the initial demand that it be directed toward practical ends.

"I would not give you the impression that it is only the electron which has given new life to modern physical science. A story of similar interest could be built around the new concepts of radiation and atomic energy as expressed in the quantum theory, or about the electron's big brother, the proton, or his rather nondescript cousin, the neutron. In the atomic nucleus is a field of further exploration of enormous promise, now only beginning to be opened up by use of radioactive materials, cyclotrons, and high-voltage generators.

"Although these things have happened very recently, no one has better described the process and intellectual value of this type of scientific research than did Aristotle in the quotation which is inscribed in Greek on the façade of the National Academy of Sciences building in Washington: 'The search for truth is in one way hard and in another easy, for it is evident that no one can master it fully nor miss it wholly. But each adds a little to our knowledge of Nature, and from all the facts assembled there arises a certain grandeur.'"

## *Achievement Aeronautical*

FOR his achievement in inventing the dynamic vibration absorber for aircraft engines, Assistant Professor Edward S. Taylor, '24, of the Institute's Course in Aeronautical Engineering was awarded the Sylvanus Albert Reed Award for 1936 by the Institute of the Aeronautical Sciences. The award, given annually for the greatest advance in aeronautical engineering of the year, is the highest in its field and carries a certificate and the sum of $250. The selection of this year's recipient was made by the 54 fellows of the Institute of the Aeronautical Sciences and the award was presented to Professor Taylor at the Institute's annual dinner in New York on January 28, just two days after his 33rd birthday.

Professor Taylor, a native of New York City, received his early education at Montclair, N. J., and his Course at Technology was mechanical engineering. After graduation he joined the staff of the Public Service Corporation in New Jersey, later going to the Wright Aeronautical Corporation, which he left to accept a position on the staff of M.I.T. During the latter part of 1934 Professor Taylor was called into consultation by the Wright Aeronautical Corporation to help in problems concerning crankshaft torsional vibration and to increase further the power output of the Wright Cyclone nine-cylinder air-cooled engines. His solution of the problem was the dynamic balancer, which is now used on all Wright Cyclone engines installed in planes of American Airlines, Transcontinental and Western Airlines, and Eastern Air Lines. This mechanism was so successful in reducing crankshaft torsional vibration to a minimum that it was not only adopted for new engines but also was sold in large quantities as replacement equipment for engines already in service.

## *Visiting Committee Reports*

DEPARTMENTAL visiting committees are appointed by the Corporation and in general are composed of two members nominated by the Alumni Council, four from the membership of the Corporation itself, and two selected at large. Twenty-two of these committees with a combined membership of 170 are

now actively serving the Institute by placing at the disposal of the departments their wide experience, their objective judgment of the departments' work and plans, and their strong support in helping the departments to gain approved objectives.

The reports of these committees are published in condensed form from time to time in these pages and provide not only interesting comment on the Institute's educational work but convincing evidence as well of the help which these committees are rendering.

This month, reports are presented on the Department of Chemical Engineering and on the Department of Geology.

## CHEMICAL ENGINEERING*

THE Committee report of last year emphasized: (1) the steady growth of enrollment in the Department, especially of graduate students; (2) the importance to continued leadership of a vital research program together with intimate contacts of the staff with industry; (3) strong indications of need for more staff.

This year (1936) the Committee was struck by the continued further growth which has now made the Department one of the largest in the Institute. In three years its enrollment of graduate students has increased from 64 to 114. Also there are 300 undergraduates. The fact that only 20 of the graduate students are graduates of the Institute and that the balance are from 56 widely scattered institutions is but one of many proofs of the acknowledged leadership in its field of the Institute's Chemical Engineering Department.

At the outset it was admitted by everyone that the Department's problems are those of healthy growth but are, nevertheless, acute; that the Department has had the hearty coöperation and support of the administration; that what should be done now is dependent in a large measure upon probable future enrollment, more particularly of graduate students; that the most difficult question is that of the sufficiency of the present senior staff and the office space allotted to it.

The Committee went over the new Institute policy of admitting undergraduates and restricting enrollment and reviewed the Department's own plans for deliberately restricting sophomore enrollment to less than its present size. With these suggestions for insuring the quality of the raw material it is in sympathy. It also considered the possible desirability of restricting the acceptance of graduate students. Here especially it found that the Department was already confining enrollment to promising students. In view of the Department's position in its field, the Committee felt that any restriction which would result in curtailing the number of good graduate students would at this time be unfair to industry and unfortunate for the Institute.

Independently of the Institute administration and the Department staff, the Committee members canvassed their personal opinions as to the probable future call for trained chemical engineers. It was their unanimous opinion that not only are highly trained chemical engineers finding opportunities in production, sales, and above all in executive and management positions, as well as research and development activities, in those process industries which have regularly used chemical engineers, but also that more and more industries are constantly recognizing the value of chemical engineers. The Committee unhesitatingly forecasts that the present demand for undergraduate and graduate education in chemical engineering is not temporary, but will grow.

The present-day leadership of the Department is due to many factors: (1) a succession of inspired department heads; (2) a young staff whose interests have been well divided between teaching, fundamental research, and consulting and research contacts with industry; (3) the research developments of one year have been part of the teachings of the next; (4) current researches have been the usual subjects of graduate problems and staff conferences; (5) an ever-present atmosphere of research, combined with amicably adjusted, but often heated staff discussion, has played an important part in building up the Department and its fundamental contributions to chemical engineering literature.

* The members of this committee for 1935–1936 were: Bradley Dewey, '09, Chairman, Frank Lovejoy, '94, Henry E. Worcester, '97, Arthur C. Dorrance, '14, Samuel Cabot, '09, George H. Taber, '13, C. M. A. Stine, and M. C. Whitaker.

## GEOLOGY*

FEW undergraduates major in geology at the Institute. One reason is that few of the students coming to the Institute are aware of (*Continued on page 162*)

* The members of this Committee for 1935–1936 were: Louis S. Cates, '02, Chairman, Charles A. Stone, '88, Harlow Shapley, Bradley Dewey, '09, Frederick G. Clapp, '01, Robert Livermore, '03, Brigadier General Edward M. Markham, and W. C. Mendenhall.

**VIBRATION ABSORBER**

*Edward S. Taylor, '24, Assistant Professor of Automotive Engineering, who has won the Sylvanus Albert Reed Award for 1936. For reasons, more detail, see opposite page*

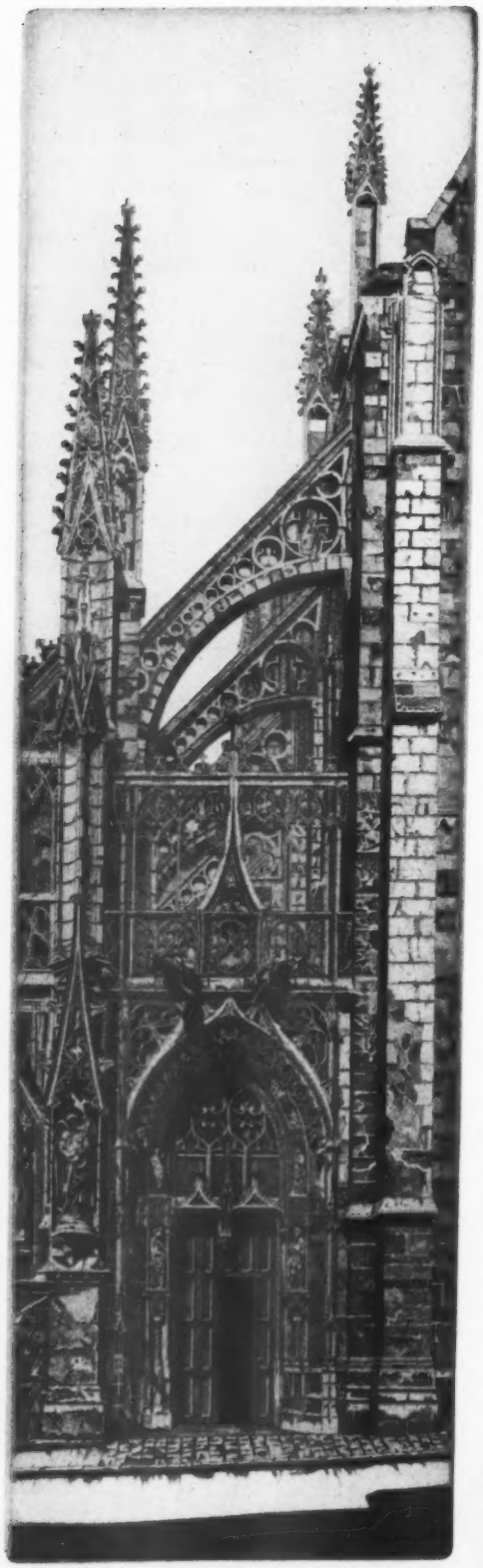
# *Our Own Etching Show*

THE success of the etching show recently staged in New York by the Society of American Etchers, Inc., demonstrated anew that traditionalism, when combined with the utmost in technical perfection, still commands the attention of the art world — this despite the surrealist exhibits which seem to be receiving the lion's share of attention in New York art galleries this winter. Realizing that comparatively few of our readers were able to view the etching exhibit while it was current at the National Arts Club, we decided upon this means of paying homage to Technology's little coterie of etchers, who still keep well to the forefront. In the select group of 156 artists whose prints were accepted for the New York show, four were at one time students at Technology.

For some time the president and leading spirit of the Society of American Etchers has been John Taylor Arms, '11, National Academician and Associate of the Royal Society of Painter-Etchers of England. "Louviers Lace," a slender, graceful plate, which he exhibited at the Society's show, proves once again his amazing mastery of the bitten line and his astounding gift of detail. (See adjacent reproduction.)

The second vice-president of the Society is Louis C. Rosenberg, '13, who has recently been elevated to the top rank of both the American and English academies. The natural sympathies of this consummate draftsman, who studied with Sir Frank Short, Royal Academician, in London's Royal College of Art, are with the English tradition of etching. Many a London print collector would claim him as England's own. He exhibited a new plate, "Via della Rotondo, Rome," a daring bit of composition, needled in his most dexterous manner. (See opposite page.)

George C. Wales, '89, has the unique distinction of being an architect turned etcher, who etches not architecture at all but boats — and boats exclusively. He is one

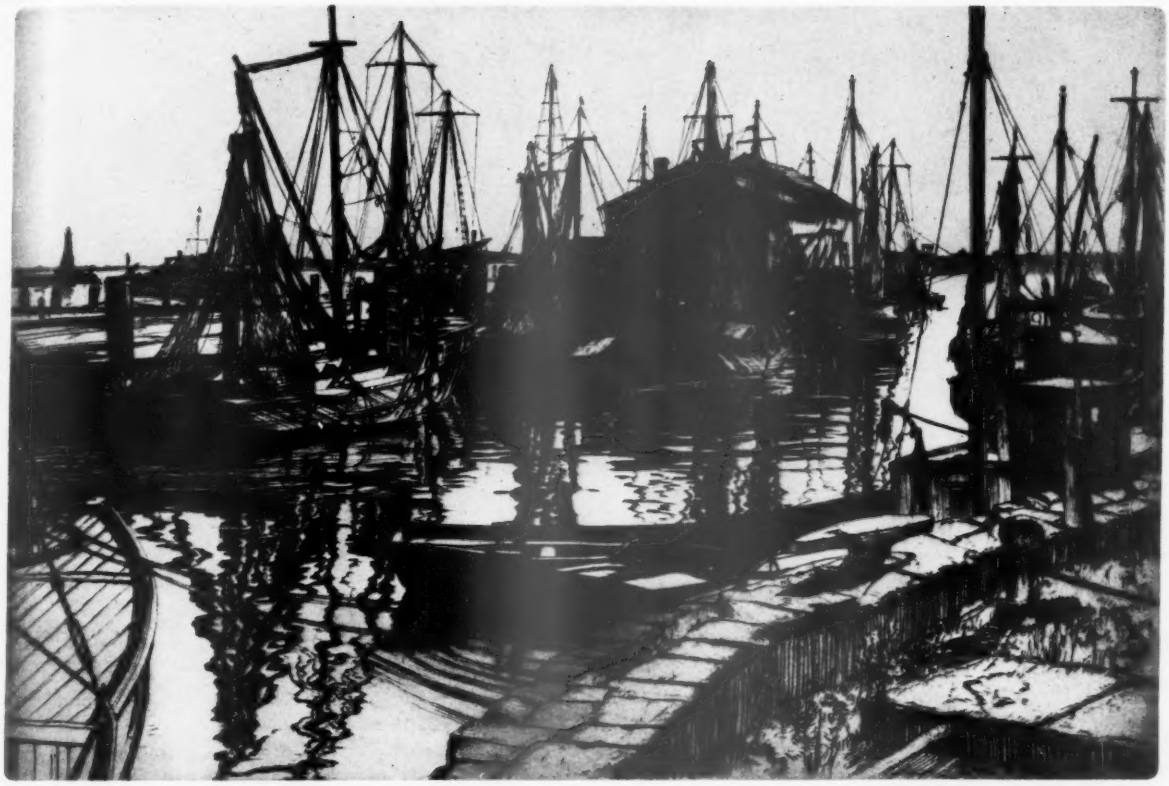


ASTOUNDING GIFT OF DETAIL

*President Arms's "Louviers Lace." Just this past month, the Grand Central Galleries had an exhibition of the work of this distinguished etcher. Under the title of "Twenty-One Years of Drawing," over 300 items were shown*

SURPASSING KNOWLEDGE OF SAIL

*George C. Wales's "Matinicus"*



DRAMATIC

*Samuel Chamberlain's "Stonington Sunset." Review Contributor Chamberlain's "Summer Street–Marblehead," reproduced in these pages last May, won the Arms Prize for technical execution*

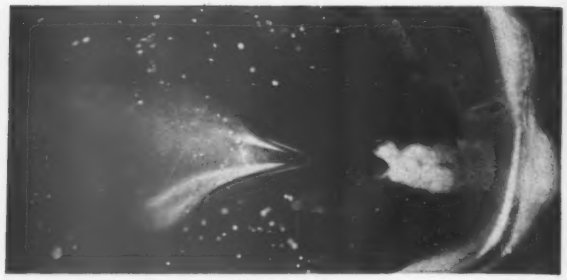
of the very few etchers who have a surpassing knowledge of sail and rigging and whose work meets with the approbation of yachtsmen — those sticklers for correct detail. His sensitive little plate, "Matinicus," (on opposite page) proves the point most convincingly.

Of the two dry points exhibited by Samuel Chamberlain, '18, one received the John Taylor Arms Prize for the best piece of technical execution in the show. This was "Summer Street–Marblehead," a calm New England scene which was reproduced in the May, 1936, issue of The Review. His other plate was "Stonington Sunset," (above), a dramatic rendition of the Portuguese fishing fleet in this old Connecticut port. Mr. Chamberlain is now giving a course in the graphic arts at M.I.T., and it may not be long before new and younger names are added to the list of Technology etchers.

DARING COMPOSITION

*Vice-president Rosenberg's "Via della Rotondo, Rome"*

Figure 1. *Internal structure of a rock-salt crystal, as revealed by electronic conduction. Islands within the crystal appear bounded by fine light lines*



NEVER BEFORE DISCERNIBLE

Figure 2. *Streamlining of the flow of electrons from cathode to anode through a crystal, as revealed by the color of copper ions. For explanation see below*

## THE INSTITUTE GAZETTE

(*Continued from page 159*)

geology as a professional field. Another is that there is no large elementary freshman course in natural sciences to acquaint them with this field. However, though it would be fine to have more students, the demand today for graduates in geology with only a bachelor's degree is too small, in contrast to those having doctors' and masters' degrees, to warrant any present attempt artificially to enlarge their number. But before leaving the question of undergraduate teaching, it must be emphasized that the Department does a large amount of service teaching for others, particularly for the mining and civil engineers.

As regards graduate students, the situation is very different. The Department has ten graduate students, most of whom are studying for doctors' degrees. All but two of these men took their bachelors' degrees elsewhere, at various institutions in this country and in Canada. Their quality and the institutions from which they come attest the reputation of the Department.

The research activity of the Department covers a wide range. Perhaps its principal emphasis is upon the geology of mineral deposits, but at the same time it is achieving outstanding results in the fields of geophysics, crystallography, and engineering geology.

At the Institute, Dr. Robley D. Evans and Dr. William D. Urry of the Physics and Chemistry Departments, respectively, have improved the techniques for the analysis of the radioactive constituents and related elements in rocks. This type of analysis serves as the most reliable basis for accurate determinations of geologic age. The work of Evans and Urry has placed the Institute far in the lead in this field. Up to the present time the work of Dr. Urry has been financed by funds raised by Dr. Lane of Tufts College, largely by grants from the Geological Society of America.

The analysis of radioactive and related constituents so successfully developed at the Institute is only one phase of the compositional study of rocks. In order to yield maximum output of scientific knowledge, it should be correlated with an equally thorough study of (1) chemical composition through chemical analysis, (2) mineralogical composition through petrographic analysis, and (3) distribution of the rare constituents among the minerals by spectroscopic analysis. These four simultaneous correlated lines of investigation would constitute an effective attack on one of the most fundamental and relatively untouched fields of research in geology. Such studies would use the accumulated knowledge and techniques of the Departments of Geology, Physics, and Chemistry and should lead to important advances and to a great number of new lines of research. Professor Mead feels that these studies would not involve elaborate new facilities.

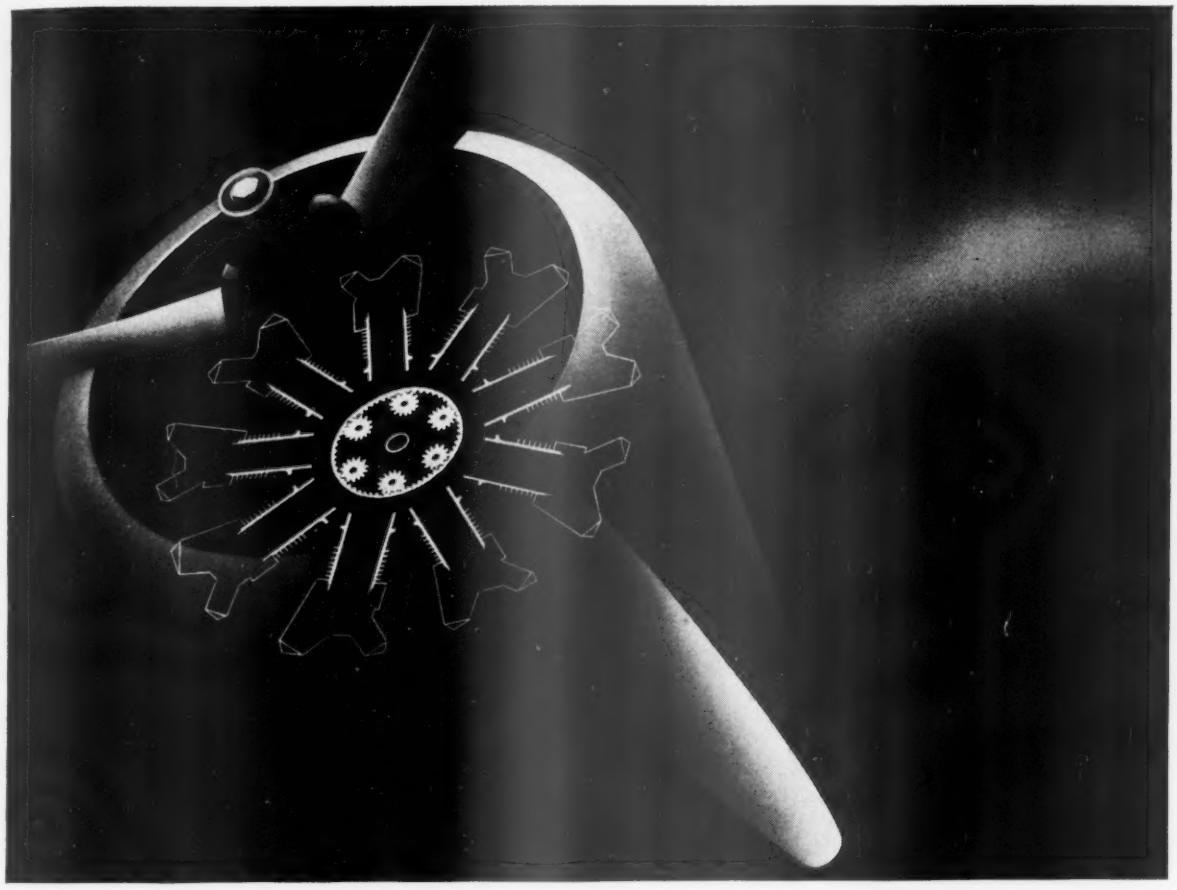
There seems to be no doubt that such a program would place the Institute in a position of prominence in the field of geology and increase the prestige of the Institute as well as of the Department. For a large part of geology it would replace wobbly, rotten, wooden foundations (based in large measure upon insufficient knowledge, sometimes upon guesswork) with real supports. It could not help but be of great ultimate value to economic geology and to more intelligent prospecting for minerals and oil.

## *Electrons on Parade*

*CHIEF among factors limiting increased efficiencies in electrical equipment is the inadequacy of present-day insulation. Generators, for example, could be built to produce higher voltages if insulating (dielectric) materials were available that could withstand higher potentials without breakdown. With better dielectrics at the disposal of the electrical engineer, even low-voltage equipment could be improved by reduction in size and weight, and the dielectric storage of energy, as in condensers, could be increased per unit of equipment weight.*

*The search for better insulation, therefore, is vital in the advancement of the electrical art, and for this reason the Department of Electrical Engineering at the Institute is vigorously carrying forward a wide program of dielectric research. The ingenious technique, described below, of viewing atoms on the march is but one facet of this research, but it is a brilliant illustration of the fundamental scientific (supplementing the equally necessary empirical) approach to an engineering problem.*

ATOMIC-PHYSICAL reactions within solids, about which only very indirect, if any, evidence had previously existed, can be (*Continued on page 172*)



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## THE FUTURE OF INVENTION

(*Continued from page 149*)

of endowed laboratories, the chances of a politically dominated research program repairing even a fraction of the damage they have already done seems indeed remote. Even in a democracy, regimentation and governmental control tend to have a paralyzing effect. Inventions depend largely upon the independent thought of active minds and it is difficult to conceive of a fertile field for invention except in an environment which encourages individual independence to the greatest possible degree. The discouraging effect of regimentation might not be so apparent in the first generation, but the effect of a national goose step would certainly show up in the second. Possibly the most serious danger confronting the future of invention throughout the world is this increasing tendency toward regimentation and political domination.

One interesting speculation as to a factor which may in the long run seriously hamper the rate of extension of science and invention is the rapidly increasing length of time required to prepare the average individual to do effective work on the frontiers of science; in other words there is a rapidly increasing amount of prior information which a scientist must master before he is competent to make additional advances. Thirty years ago a man with a bachelor's degree from a good university could carry out advanced research without serious competitive handicap. Today a man with even a doctor's degree is considered to be inadequately prepared to do outstanding research in many branches of science. If this process continues, our men will pass their prime so far as their inventive faculties are concerned before they reach the level where they can begin pioneering work. Some would remedy this by earlier and more intensive specialization in the training of our scientists, but I feel that this would be a serious mistake, as our scientists need to know more, rather than less, of the social implications of their work, and only a broad training can be an adequate foundation for a life devoted to research. This situation can be improved by more efficient methods of education, particularly in the elementary and high schools, for individuals who show real promise of scientific ability. Our present public school system is very wasteful of the time of the small percentage of students who are really brilliant, and we must find some method of discovering this potential brilliance and giving it more expeditious training if we are to maintain the present pace of scientific advance.

Our patent system as a whole has demonstrated its tremendous value as an incentive to research and invention, and its administration has been excellent in view of the many difficult problems it has had to handle. However, our patent system must be expected to evolve as our civilization evolves, and it must be studied to make certain that the restrictions it imposes are no greater than really necessary to accomplish its desired purposes. It is obvious, of course, that every invalid patent whose issuance the Office permits or a court orders, and every unnecessary delay which occurs in the prosecution or adjudication of a (*Continued on page 166*)

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## THE FUTURE OF INVENTION

(*Continued from page 164*)

patent is an undesirable and unnecessary burden on both science and industry. Anything which can be done to make the process of granting patents more expeditious and more reliable is highly desirable. I have studied with interest and care the report of the committee of the Science Advisory Board on the relation of the patent system to the stimulation of new industries and concur heartily with its recommendations, particularly as to the desirability of, and the methods recommended for, increasing the presumption of validity of issued patents and making possible the more expeditious handling of cases both within and without the Patent Office. It is indefensible when, as has happened on several occasions, a patent issues after 10 or 15 years in the Patent Office and purports to dominate an industry which has sprung up in the interim. The hazard of such an occurrence is always hanging over legitimate industry and this ever-present possibility is probably, in the long run, more harmful than in the rather rare cases in which it does occur. In any case effective steps should certainly be taken to make such occurrences impossible. Just as the development of new inventions is requiring men of higher caliber, so the caliber and training of Patent Office personnel must continue to improve, their salary and average tenure of office should be increased, and some means taken to make examiners more familiar with the general background of unpublished information and practice in our industries.

Now that a greater and greater proportion of our inventions and discoveries is made as the result of planned attack by our large industrial laboratories, it is apparent that the domination of a new field of invention by basic patents issued to one company is necessarily a deterrent to other companies who might otherwise enter this field of investigation. Actually, however, experience has shown that even comparatively late comers in such new fields can reasonably expect, if they prosecute their research vigorously and intelligently, to find alternative methods or improvements which will entitle them to a place in the picture. Some one has given this process the apt name "circuminvention." It is also true that in many cases changing conditions in an industry cause numerous laboratories to start work almost simultaneously along similar lines and in this case the existence of our patent system is definitely a stimulus to speedy and effective research; there is frequently a race to see which group can secure the best patent position. Unfortunately the ultimate result of such a race is generally the issuance of a considerable number of overlapping or supplementary patents so that the process which is ultimately found to be best frequently infringes or appears to infringe the patents of several different individuals or companies, and many other applications are tied up in interferences. Fortunately there has been an increasing tendency in recent years for companies in such a position to avoid the expense and delay attendant upon interference and infringement litigation by arbitrating their interference and exchanging cross licenses to both past and future developments in a given narrow field. (*Continued on page 168*)

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## THE FUTURE OF INVENTION

*(Continued from page 166)*

Such an agreement generally involves provisions for the licensing of others upon reasonable terms and for a division of royalties based upon the best estimate of the parties as to the relative value of their respective positions. Such agreements also usually involve agreement by each party to conduct further research in the field in question.

There have been several recent attempts to arouse opposition to such arrangements, labeling them as "patent pools," without any real attempt to study their provisions. Certainly the ordinary cross-licensing arrangement among companies actively engaged in research can serve only to remove part of the barriers to use originally set up by the patent system, thus removing obstacles both to research and to commercial development and decreasing wasteful litigation. It makes enough patents and (what is frequently more important) combined experience available to a licensee so that he can really operate the best available process without having to acquire licenses from several different sources. Such licenses in general protect the licensee not only from issued but from all future patents in the defined field which might issue to any of those in the cross-licensing group. The only party which would seem to have any cause for complaint against such an arrangement is the racketeer who hopes to infringe with impunity while the owners of the patents fritter away the life of their patents in lengthy and often suicidal litigation with one another.

Since such cross-licensing agreements definitely tend to promote not only research and invention but the prompt commercial application of these inventions, the question might be raised as to why cross-licensing agreements covering entire industries would not be still better in this respect. Such arrangements have been tried in a number of industries and in general they have not been successful for any considerable period. Apparently the main difficulty has been that they have run up against human nature: As soon as any individual or company realizes that all its competitors will have the same rights as it has to anything it may develop, there is a natural tendency to leave the expense of research and development to one's competitors and hope to acquire a "free ride." Other companies which, as a matter of principle, continue their research become irritated sooner or later when the fruits of their research are appropriated by others who have contributed nothing. In general, cross-licensing agreements have been successful only where they were either backed by a definite agreement to contribute ratably to support most of the research in the field, or have been made between individual companies who have confidence in one another's desire and ability to contribute their share to the heavy expense of research and development.

Concentrating as I have on possible threats to the future of invention, I hope I have not given the impression that I am pessimistic with regard to its future. My purpose has rather been to point out that the growth of science and invention is not something which we can rely upon to continue auto- (*Concluded on page 169*)

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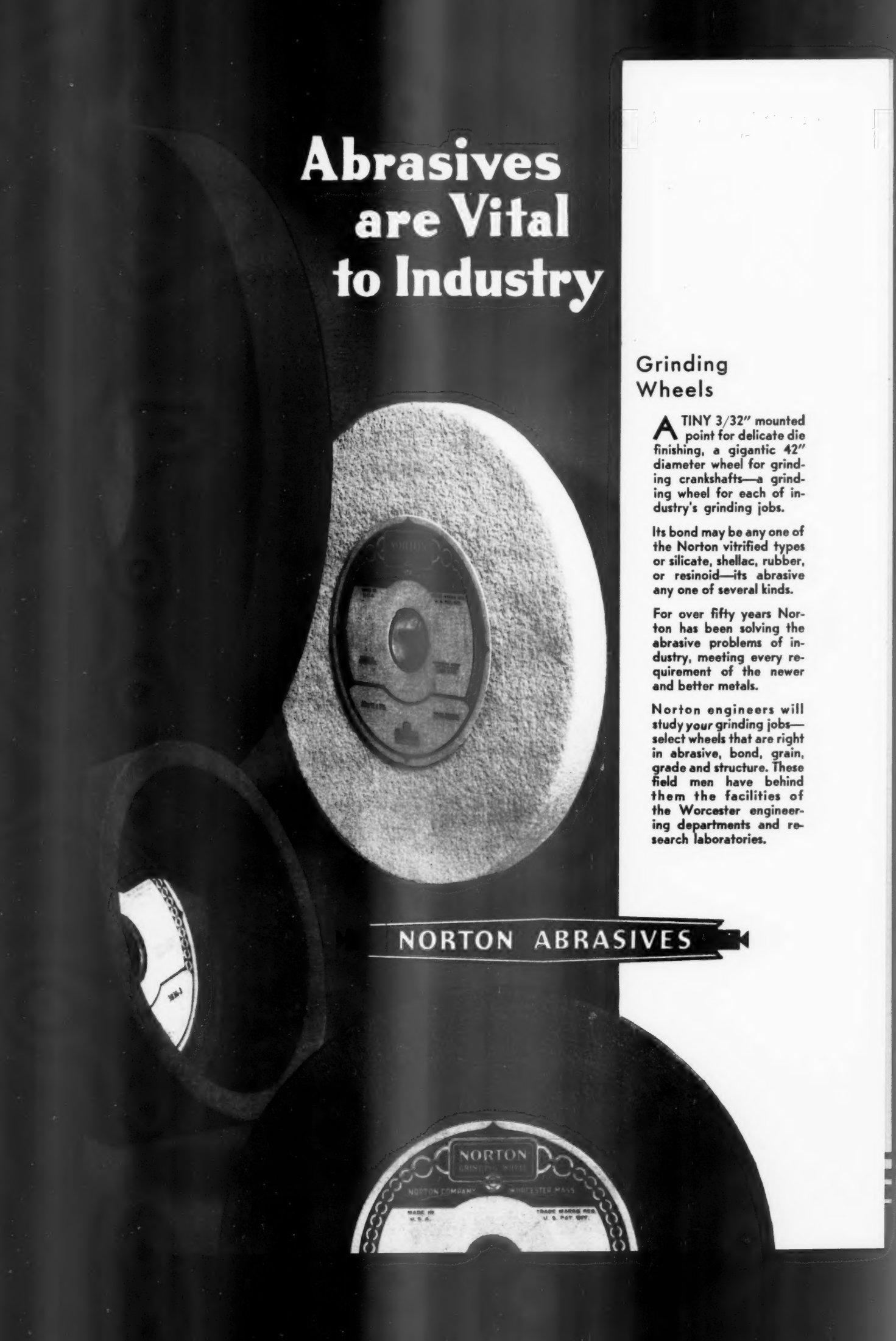
*169*)

# Abrasives are Vital to Industry

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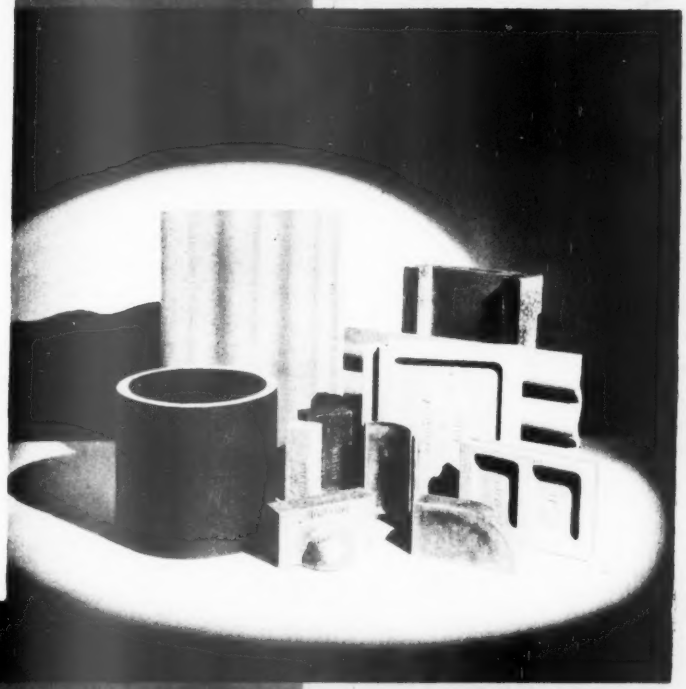

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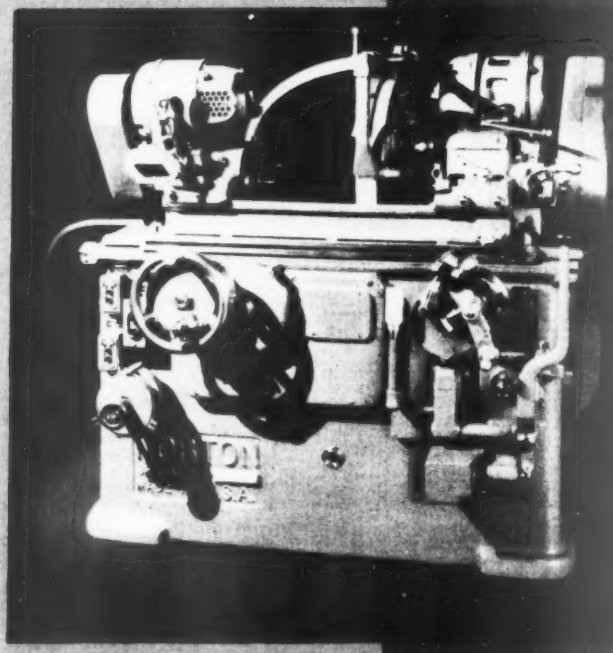

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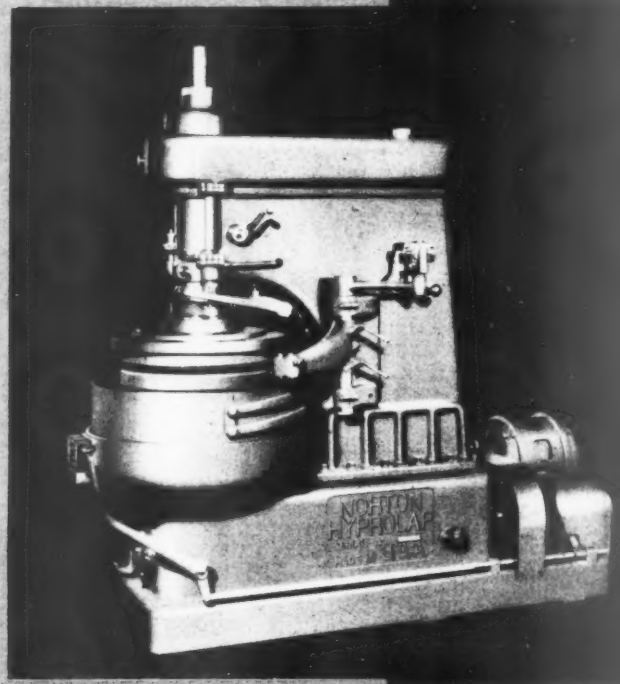


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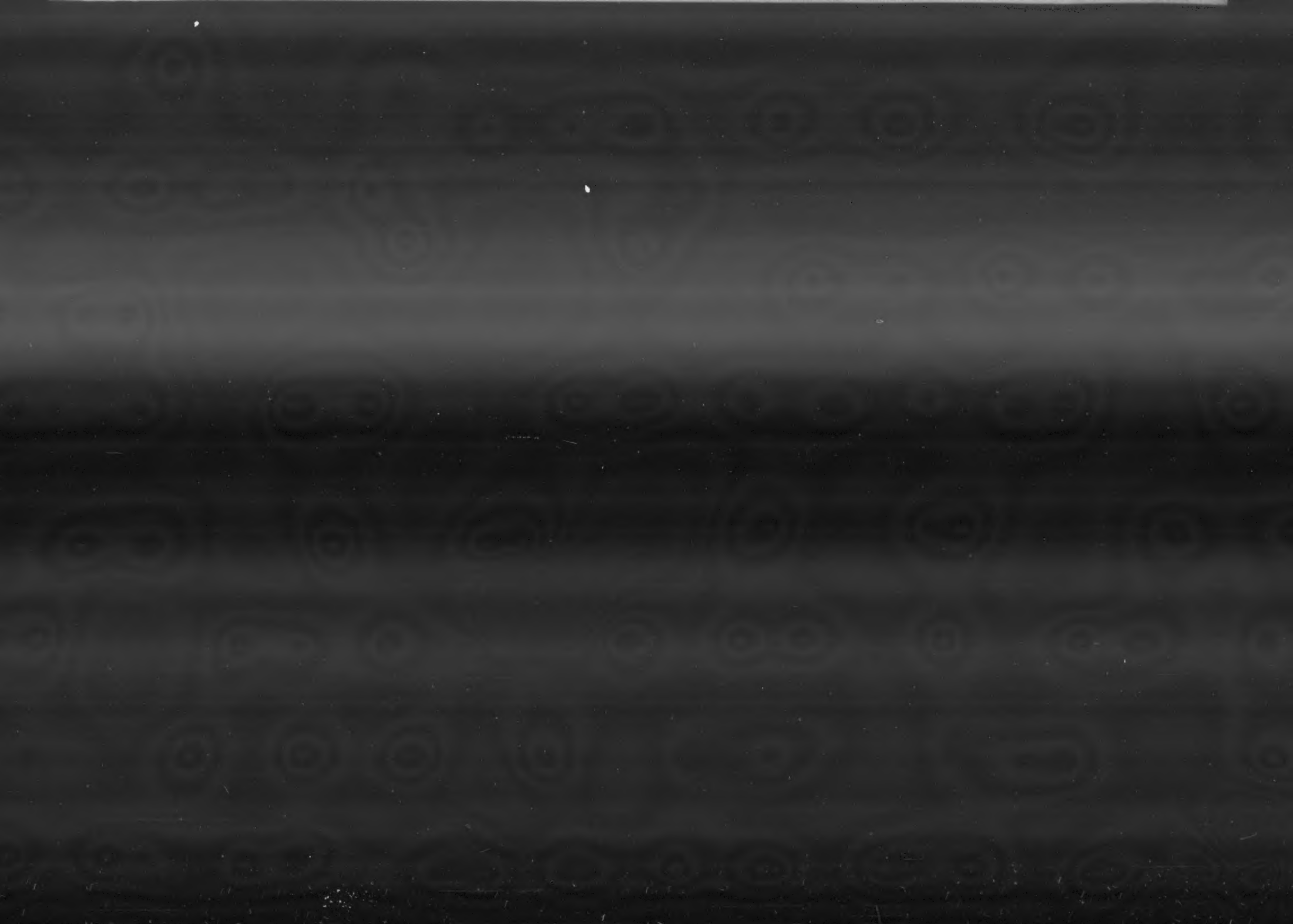
**NORTON MACHINES**



## THE FUTURE OF INVENTION

(*Concluded from page 168*)

matically without any effort or attention on our part. Our inventors and scientists are probably our greatest national asset and one which we must foster and conserve if we are to retain it. Incentives to invention must be maintained, and obstacles removed. Of the future of research and invention in the European dictatorships I am seriously apprehensive, but of their future under our American democracy and a reasonably evolving patent system, I am not only optimistic but enthusiastic. This is not the end; the future of invention will dwarf its past.

## SCIENCE AND AMERICAN LITERATURE

(*Concluded from page 154*)

which Dos Passos borrowed from the movies, Dreiser's pseudophilosophic chemism, Cabell's flight to Poictesme, Robinson's determined preoccupation with the unmachined backwaters, Hemingway's desperately objective analyses of war's human by-products are precipitates of the same reagent. In the immediate present, both Sinclair Lewis' "It Can't Happen Here" and the political system which it attacks would be physically impossible without the public-address system provided by engineering. The pleasant sophistication of S. N. Behrman's politely futile loafers and the grim desperation of Clifford Odets' ominously radical workers are products of the same machines.

The generation of new subject matter is not the only way in which science has served, well or ill, recent American literature. Beyond altering the setting and the characters with which a creative writer deals, science has changed the very style and method with which he works. The objective technique of the laboratory is, as Hemingway himself asserts, the most efficient and, therefore, the most desirable way of fixing for a moment a sequence of human activity, according to one school of creative thought. At the other pole, the nebulous concept of a time-space continuum of multiple dimensions, no beginning and probably no end, finds its literary prototype in the stream-of-consciousness, godchild of Einstein and Freud.

No time is needed to show that the immanence of science in American life today is producing a literature that cannot be explained in the older terminology. Even if the historical importance of the older influences could be extended to explain and evaluate current literature, there is nothing in their history to justify hope for their continuance. Literary criticism in America in the century to come must be ready to reckon with a science that is not only dominant but also self-conscious.

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## CHARLES HAYDEN, '90

(*Concluded from page 152*)

Later, when the Corporation decided that the Institute's greatest need was a great loan fund, Mr. Hayden again played a major part in raising and administering the fund, and contributed $150,000. Two years ago, with the Loan Fund in successful operation, the Institute found need for additional research funds and again Mr. Hayden lent active aid by becoming chairman of the Research Associates.

In many other Institute enterprises his counsel and help were sought and obtained in the fullest measure. Always he seemed to be dominated by the feeling that "life is but a little holding, lent to do a mighty labor," and by the indefatigability with which he worked and built and helped, he demonstrated how mighty one man's work can be. Despite his tremendous responsibilities, he remained throughout his life, as he impressed his classmates when an undergraduate at Technology, a gracious, highly social, friendly person.

Mr. Hayden's rise to a dominant position in the financial world began almost immediately after his graduation. In February, 1892, he organized, with Galen Stone, the firm of Hayden, Stone and Company and became, when only 21, a member of the New York Stock Exchange. At that time the primary interest of Mr. Hayden and his firm was in copper companies as a result of his vision of the expansion to come in the electrical industry. The firm financed many new copper enterprises, and Mr. Hayden eventually became chairman of the finance committee of the Kennecott Copper Corporation and its subsidiaries, Nevada Consolidated Copper Corporation and Utah Copper Corporation. At the time of his death he was on the directorates of more important companies than any other man in the United States. In addition to copper, the industrial enterprises in whose management Mr. Hayden participated included nickel, shipping, sugar, investment trusts, office equipment, fertilizer, baking, cement, oil, railroad equipment, textiles, trucks, elevators, hotels, and insurance.

In addition to his many gifts to the Institute, Mr. Hayden during his lifetime generously aided divers good causes. His gift of $150,000 for the completion of the New York Planetarium, which now bears his name, and his leadership in 1935 of the United Hospitals Campaign were probably the best known of his recent philanthropies. Through the Charlhay Corporation created by him he systematically supported many charitable organizations, particularly those contributing to the needs of youth. The foundation established in his will insures the perpetuation of this carefully conceived aid.

Mr. Hayden's death calls attention anew to the large and impressive group of Technology graduates who have become major figures in American industry and who have combined with their financial genius deep understanding of the social needs of our time and the will and vision to make permanent contributions to the welfare of American life. Certainly this group, as Mr. Hayden has specifically demonstrated, has helped to build the Massachusetts Institute of Technology, and to make it an ever greater institution through their intelligent loyalty and understanding support.

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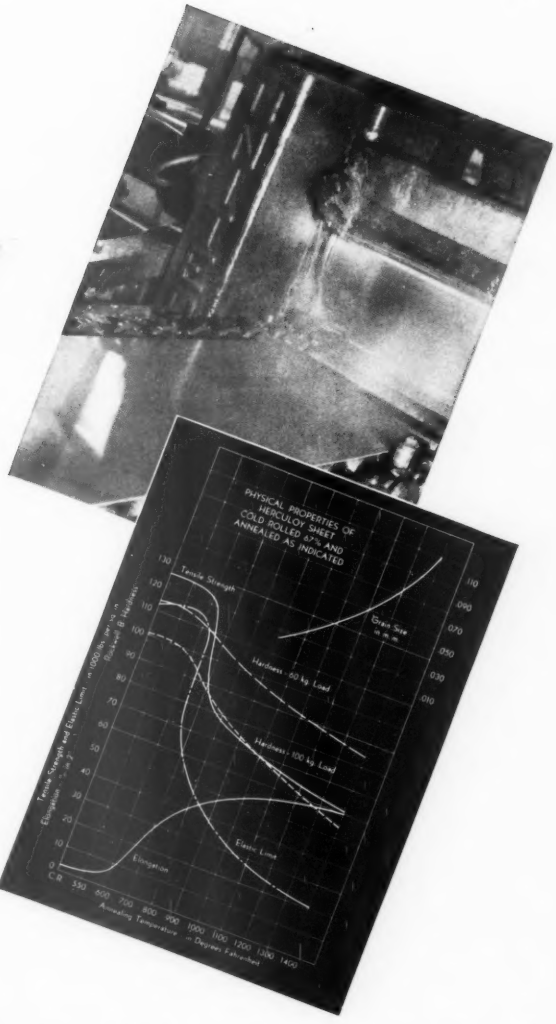
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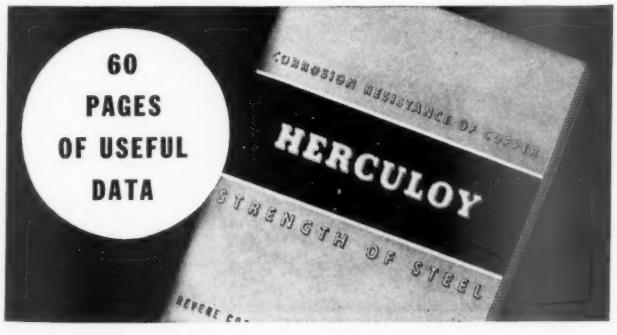


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## THE INSTITUTE GAZETTE

(*Continued from page 162*)

visibly demonstrated as a result of studies conducted by Professor Arthur R. von Hippel of the Electrical Engineering Department at the Institute. Dr. von Hippel is continuing at Technology a program of research into electronic and ionic conduction through solids and into the electrical breakdown of insulators, which he began some years ago at the University of Göttingen.

Dr. von Hippel's latest investigation had its starting point in the observation of Stasiw at Göttingen, who found that in a crystal of rock salt, heated to about 500 degrees C. and placed between electrodes, a cherry-red cloud appears at the cathode side — as current is passed — and passes through the crystal. Its rate of progress is much faster than that at which ions could move through the medium, so that some other explanation for the phenomenon on an electronic basis is necessary. This Dr. von Hippel has found. He has been able to show that electrons enter the crystal, move along in preferred crystallographic directions, and slow down and become trapped by the local distortion of the crystal-lattice which they themselves bring about. As a sign of their local stoppage in the crystal, the color appears. Heat vibration, however, after some time breaks the binding force, the electron moves some distance but becomes trapped again, and consequently the color-cloud moves along also, showing the points where electrons are caught.

Characteristics of the internal structure of the crystal, including failures in it, which never before were discernible, are made clearly evident as a result of this technique. The color produced by the electrons is sensitive to imperfections in the structure, as appears in Figure 1, (page 162) where boundaries of internal areas within the crystal, corresponding in a sense to fault lines in the earth's crust, are seen.

In another way also Dr. von Hippel's study makes it possible for the investigator to get inside the crystal and observe what is going on during the passage of a current. The electrons act like a developing solution to reveal the presence of ions which do not belong in the original crystal.

Copper ions, for instance, which enter from a copper anode and which would otherwise be invisible in the space-grating, are in a sense dyed, in a manner somewhat resembling the staining used in microbiology, by becoming linked to electrons and as a result indicating their presence by a pink color at the place where they are fixed. Conversely, because the copper ions thus show the presence of electrons, they can be used to show the outlines of the electron current. Their pinkish color performs for the electron flow the same function that ink


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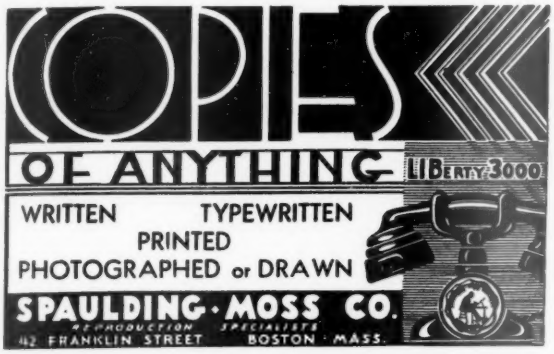
performs in indicating the flow of water to an orifice, high lighting the streamlines within the crystal as the dye marks streamlines in hydrodynamic experiments. Figure 2 illustrates this effect.

Through the method established by Dr. von Hippel's research, other phenomena hitherto necessarily known only in theory can be raised to the visible level. Among these are the stability of chemical compounds in the crystal, and the phenomenon of impact ionization, which destroys insulating material by an electric breakdown. This last is of special practical importance, for if the mechanism involved in such breakdowns is learned, remedies for it may be devised and better electric insulators designed.

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## THE TREND OF AFFAIRS

*(Concluded from page 145)*

with a free period of the shorter duration. Later it was found that a similar wave caused by the great Siberian meteor in 1908 was propagated with the same speed.

A hint of the final answer was found in yet another difficulty. This arose in connection with the use of the so-called dynamo theory to interpret diurnal variation of the earth's magnetic field. According to this theory, the oscillation of the atmosphere across the permanent magnetic field of the earth causes electric currents to circulate in the Kennelly-Heaviside layers — strata of ionized air in the upper atmosphere — and these currents in turn produce a magnetic field which we observe at the ground as a small oscillation in the magnetic field of the earth. But the variation in sign of this magnetic field, it was shown by Chapman in 1919, is such that it can occur only if the atmosphere aloft swings in the opposite direction to the atmosphere below.

The clue to the solution of this problem was found by Dr. Pekeris in the anomalous propagation of sound from gunfire. It has been known since the World War that there are two zones of audibility, one within a radius of 30 miles from the source and another between 60 and 90 miles. Between them is the zone of silence which caused firing at the recent exercises of the Pacific Fleet to be heard at inland stations but not along the coast.

Dr. Pekeris' explanation of this phenomenon is that sound waves are speeded up and bent downwards in the upper atmosphere by a hot layer, much as radio waves are reflected by the conducting layers. If the existence of the hot layer be assumed, it is found that the atmosphere would have two periods of oscillation: 10½ hours and 12 hours. In the atmospheric mode having a period of 12 hours, there is no oscillation at the height of 20 miles; the atmospheres above and below that level swing in opposite directions. Without the hot layer above, however, this mode of oscillation could not exist in the atmosphere. Assuming the hot layer, we have a synthesis of Kelvin's 12-hour period, Chapman's weak lunar tides, Taylor's 10½-hour period, and Chapman's varying magnetic field conditions by opposing atmospheric swings, as well as an explanation for the zone of silence in the propagation of sound.

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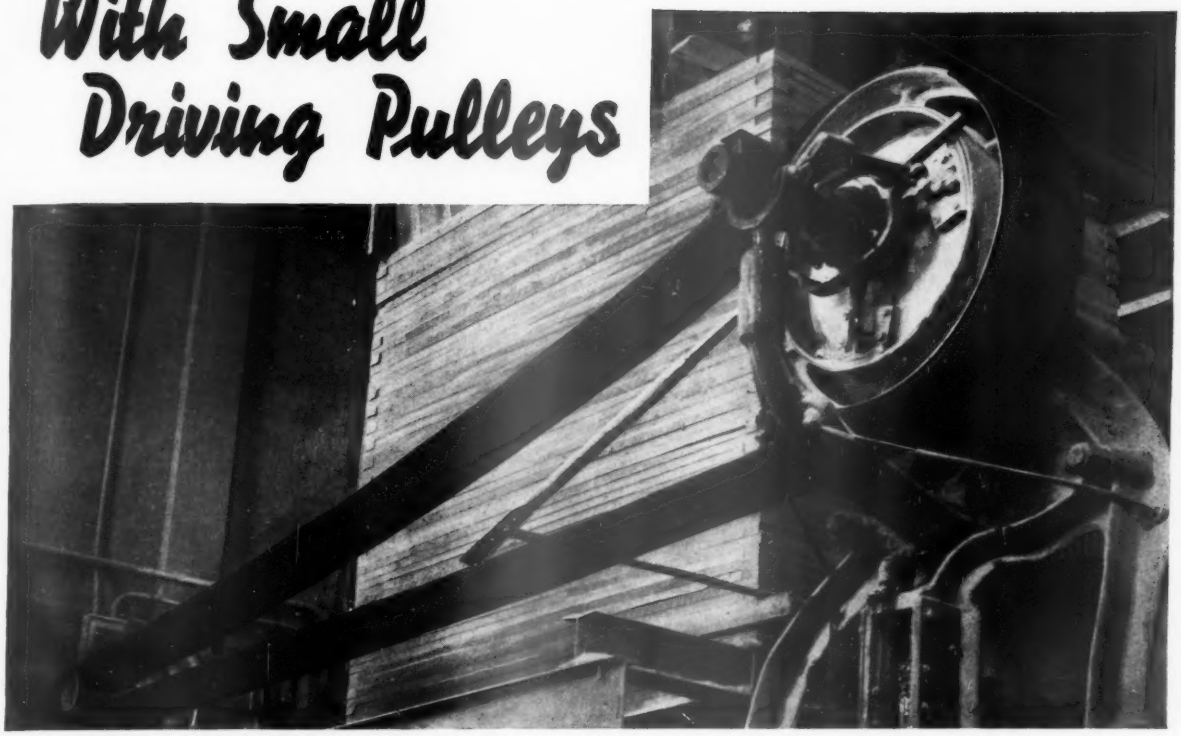

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